UNIVERSITY^{OF} BIRMINGHAM University of Birmingham Research at Birmingham

On the Two Approaches to Incorporate Wave-Particle Resonant Effects Into Global Test Particle Simulations Lukin, A. S.; Artemyev, A. V.; Zhang, X.-J.; Allanson, O.; Tao, X.

DOI: 10.1029/2023JA032163

License: None: All rights reserved

Document Version Peer reviewed version

Citation for published version (Harvard):

Lukin, AS, Ártemyev, AV, Zhang, XJ, Állanson, O & Tao, X 2024, 'On the Two Approaches to Incorporate Wave-Particle Resonant Effects Into Global Test Particle Simulations', *Journal of Geophysical Research: Space Physics*, vol. 129, no. 2, e2023JA032163. https://doi.org/10.1029/2023JA032163

Link to publication on Research at Birmingham portal

Publisher Rights Statement: An edited version of this paper was published by AGU. Published (2024) American Geophysical Union.

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

•Users may freely distribute the URL that is used to identify this publication.

•Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.

•User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?) •Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

On the two approaches to incorporate wave-particle resonant effects into global test particle simulations

1

2

3 4

17

Key Points:

A. S. Lukin $^{1,2},$ A. V. Artemyev $^{3,2},$ X.-J. Zhang $^{1,3},$ O. Allanson $^{4,5,6},$ X. Tao 7,8,9

5 6	¹ Department of Physics, University of Texas at Dallas, Richardson, TX, USA ² Space Research Institute, RAS, Moscow, Russia
7	³ Earth, Planetary, and Space Sciences, University of California, Los Angeles, Los Angeles, CA, USA
8	⁴ Space Environment and Radio Engineering; Electronic, Electrical and Systems Engineering; School of
9	Engineering, University of Birmingham, Birmingham, UK
LO	⁵ Department of Earth & Environmental Sciences, University of Exeter, Penryn, UK
1	⁶ Department of Mathematics, University of Exeter, Exeter, UK
12	⁷ CAS Key Laboratory of Geospace Environment, Department of Geophysics and Planetary Sciences,
13	University of Science and Technology of China, Hefei, China
4	⁸ CAS Center for Excellence in Comparative Planetology, Hefei, China
15	⁹ Mengcheng National Geophysical Observatory, University of Science and Technology of China, Hefei,
16	China

• We discuss two approaches to incorporate resonant effects into	test particle sim-
¹⁹ ulation models	
$_{\rm 20}$ $$ $$ $$ $$ $$ Detailed approaches have been shown for continuous stochastic	c differential equa-
tions (SDE) and the mapping technique, respectively	
• In contrast to continuous SDE, the mapping technique allows of	one to simulate non
23 linear resonant effects	

$Corresponding \ author: \ A. \ S. \ Lukin, \verb"as.lukin.phys@gmail.com" \\$

24 Abstract

Energetic electron dynamics in the Earth's radiation belts and near-Earth plasma sheet 25 are controlled by multiple processes operating on very different time scales: from storm-26 time magnetic field reconfiguration on a timescale of hours to individual resonant wave-27 particle interactions on a timescale of milliseconds. The most advanced models for such 28 dynamics either include test particle simulations in electromagnetic fields from global 29 magnetospheric models, or those that solve the Fokker-Plank equation for long-term ef-30 fects of wave-particle resonant interactions. The most prospective method, however, would 31 be to combine these two classes of models, to allow the inclusion of resonant electron scat-32 tering into simulations of electron motion in global magnetospheric fields. However, there 33 are still significant outstanding challenges that remain regarding how to incorporate the 34 long term effects of wave-particle interactions in test-particle simulations. In this paper, 35 we describe in details two approaches that incorporate electron scattering in test par-36 ticle simulations: stochastic differential equation approach and the mapping technique. 37 Both approaches assume that wave-particle interactions can be described as a probabilis-38 tic process that changes electron energy, pitch-angle, and thus modifies the test parti-39 cle dynamics. To compare these approaches, we model electron resonant interactions with 40 field-aligned whistler-mode waves in dipole magnetic fields. This comparison shows ad-41 vantages of the mapping technique in simulating the nonlinear resonant effects, but also 42 underlines that more significant computational resources are needed for this technique 43 in comparison with the stochastic differential equation approach. We further discuss ap-44 plications of both approaches in improving existing models of energetic electron dynam-45 ics. 46

47 **1** Introduction

One key element in substorm magnetosphere dynamics is plasma sheet injections 48 into the inner magnetosphere (Baker et al., 1996; Birn et al., 1997; Nakamura et al., 2002; 49 Angelopoulos et al., 2008; Gabrielse et al., 2012). Simulations of the energetic particle 50 transport during such injections require modeling of large-scale magnetic field reconfig-51 uration and particle responses to a wide variety of kinetic processes, such as wave-particle 52 resonant interactions and scattering by the magnetic field gradients. The most advanced 53 approach here is the test-particle modeling in electromagnetic fields of global (magne-54 tosphere) MHD or hybrid simulations (e.g., Peroomian & El-Alaoui, 2008; Birn et al., 55 2004; Ashour-Abdalla et al., 2005). This approach can well resolve meso-scale electro-56 magnetic field structures, like plasma injection fronts (e.g., Wiltberger et al., 2015), and 57 can reproduce main details of energetic electron (Ashour-Abdalla et al., 2011; Liang et 58 al., 2014; Pan et al., 2014; Birn et al., 2014, 2022; Zhou et al., 2018; Sorathia et al., 2018) 59 and ion (Peroomian & Zelenyi, 2001; Birn et al., 2015, 2017; Ukhorskiy et al., 2018) trans-60 port and energization. MHD simulations with sufficiently high spatial resolution can re-61 produce magnetic field gradients around injection (dipolarization) fronts and magneto-62 tail current sheets, and thus may adequately describe electron scattering by magnetic 63 field-line curvatures (Eshetu et al., 2018, 2019; Desai et al., 2021). Moreover, global hy-64 brid simulations resolving ion kinetics (Lin et al., 2014; Lu et al., 2016, 2017) can repro-65 duce kinetic Alfven wave dynamics (Lin et al., 2017; Cheng et al., 2020), making it pos-66 sible to simulate the plasma sheet electron and ion acceleration by field-aligned transient 67 electric fields (i.e., the main ion-kinetic feature of plasma injections (Chaston et al., 2012, 68 2015; Ergun et al., 2015; Hull et al., 2020)). Although schemes to include electron ki-69 netics into global simulations are under development and verification (e.g., Chen et al., 70 2017; Walker et al., 2018; Alho et al., 2022), neither existing global MHD nor global hy-71 brid simulations can resolve electron-scale waves, and thus cannot describe the wide range 72 of electron resonant phenomena associated with plasma injections (see discussion in Mozer 73 et al., 2015; Malaspina et al., 2018; Ukhorskiy et al., 2022; Artemyev, Neishtadt, & An-74 gelopoulos, 2022). 75



Figure 1. Schematic of four main time-scales of electron motion during plasma sheet injections into the inner magnetosphere. Four main time-scales: electron gyroperiod $\tau_g = mc/eB \sim 10^{-3}$ s (with a typical magnetic field magnitude of B = 10nT), electron bounce period $\tau_b \sim 4L_{CS}/v_0 \sim 10^{-1}$ s (with the current sheet thickness being $L_{CS} = 1R_E$ and v_0 being the thermal velocity of 100 keV electrons), $\tau_D \sim L_x/v_x \sim 10^3$ s is electron transport time by plasma flows ($v_x \sim 100$ km/s), $\tau_{\phi} = 2\pi R/v_{\phi} \sim 10^4$ s is the electron azimuthal drift period (the radial distance of the injection region is assumed to be $R = 6R_E$ and the electron energy is 100 keV).

It is actually rather challenging to incorporate wave-particle resonant interactions 76 into test particle simulations of plasma injections, because of their vastly different timescales. 77 Figure 1 shows a schematic of the four main types of electron motions: cyclotron rota-78 tion with the timescale of $\tau_g \sim 10^{-3}$ s, bounce motion between magnetic mirrors with 79 the time scale of $\tau_b \sim 10^{-1}$ s (for 100keV electrons), earthward transport with the time-80 scale of $\tau_D \sim 10^3$ s, and azimuthal motion around the Earth with the time-scale of $\tau_{\phi} \sim$ 81 10^4 s (for 100keV electrons). The ratio of the timescales of the fastest and the slowest 82 motions can be $\tau_{\phi}/\tau_g \sim 10^7$ or $\tau_D/\tau_g \sim 10^6$. Individual wave-particle interaction, e.g., via cyclotron resonance, occurs over $\sim \tau_g$, and thus such interactions may not be directly 83 84 incorporated into test particle simulations of the plasma injections, which occur over \sim 85 τ_D . 86

A possible solution of this problem was proposed by Elkington et al. (2018, 2019), 87 who suggest that wave-particle interactions can be incorporated as stochastic perturba-88 tions of electron test orbits (see also Michael et al., 2023; Chan et al., 2023). The sim-89 plified version of this approach combines test particle equations of motion and contin-90 uous stochastic differential equations (SDEs), which are characteristics for the Fokker-91 Plank diffusion equation (Tao et al., 2008; Zheng et al., 2014). The Fokker-Plank equa-92 tion is used in the quasi-linear theory (Vedenov et al., 1962; Andronov & Trakhtengerts, 93 1964; Kennel & Engelmann, 1966), which describes electron scattering by low intensity 94 waves (see Karpman, 1974; Albert, 2001, 2010; Frantsuzov et al., 2023, for discussions 95 on the wave intensity limitations in inhomogeneous background magnetic field, like in 96 the Earth's magnetosphere). Applications of the quasi-linear diffusion approximation has 97 been well developed for the Earth's magnetosphere (Lyons & Williams, 1984; Schulz & 98 Lanzerotti, 1974), and the main parameters of this approximation, the diffusion rates, 99 are widely evaluated and used for the observed wave characteristics in the magnetotail 100 (e.g., Panov et al., 2013; Zhang et al., 2015; Ni et al., 2011, 2012, 2016) and inner mag-101 netosphere (see reviews by Shprits et al., 2008; Artemyev, Agapitov, et al., 2016; Li & 102 Hudson, 2019; Thorne et al., 2021, and references therein). 103

The main limitation of the quasi-linear models is the requirement of a small wave 104 intensity. A significant portion of most intense electromagnetic whistler-mode waves (Wilson 105 et al., 2011; Tyler et al., 2019; Zhang et al., 2018, 2019), electrostatic whistler-mode waves 106 (Cully et al., 2008; C. Cattell et al., 2008; C. A. Cattell et al., 2015; Agapitov et al., 2014, 107 2015), and electromagnetic ion cyclotron waves (e.g., Wang et al., 2017; Tonoian et al., 108 2022) can exceed their threshold amplitudes and likely resonate with electrons nonlin-109 early. Such nonlinear resonant interactions include effects of phase bunching and phase 110 trapping (see Nunn, 1971; Karpman et al., 1975; Inan & Bell, 1977; Solovev & Shkliar, 111 1986; Albert, 1993; Itin et al., 2000), which can significantly modify the characteristics 112 of wave-particle interactions (see reviews by Shklyar & Matsumoto, 2009; Albert et al., 113 2013; Artemyev, Neishtadt, Vainchtein, et al., 2018, and references therein). Nonlinear 114 effects can be incorporated into the kinetic equation (i.e., modified Fokker-Plank equa-115 tion) for electron distribution functions (e.g., Omura et al., 2015; Hsieh & Omura, 2017; 116 Artemyev, Neishtadt, et al., 2016; Artemyev, Neishtadt, Vasiliev, & Mourenas, 2018), 117 but the corresponding characteristic equations will be different from those in the SDE 118 approach. The main difference is the probability distribution function of pitch-angle/energy 119 jumps due to resonant interactions: nonlinear effects cannot be described by Gaussian 120 probability distributions that are often adopted to model the diffusive scattering within 121 SDE approach. Recently, an alternative to SDE approach was proposed in (Artemyev, 122 Neishtadt, Vainchtein, et al., 2018; Zheng et al., 2019), where a non-Gaussian probabil-123 ity distribution of pitch-angle/energy jumps has been incorporated into equations of mo-124 tion for resonant electrons. This approach resembles the generalization of the classical 125 mapping technique (e.g., Chirikov, 1979; Zaslavskii et al., 1989; Khazanov et al., 2014) 126 to systems with a finite probability of very large pitch-angle/energy jumps due to phase 127 trapping (see Artemyev et al., 2020). The mapping technique can reproduce many ob-128 served effects of nonlinear wave-particle interactions (e.g., Zhang et al., 2022; Artemyev, 129 Zhang, et al., 2022) and in principle can be incorporated into test-particle codes (Artemyev, 130 Neishtadt, & Angelopoulos, 2022). Therefore, both SDE and mapping technique can be 131 used to include wave-particle resonant interactions into models of energetic electron dy-132 namics in global electromagnetic fields provided by MHD/hybrid simulations. The map-133 ping technique should generalize the SDE approach, but it is yet to be investigated whether 134 the mapping equations can describe diffusive scattering and nonlinear resonant effects 135 with the same accuracy level. The mapping technique usually adopts analytical equa-136 tions to model pitch-angle/energy jumps, which do not include diffusive scattering (Artemyev 137 et al., 2020). Recently Lukin et al. (2021) has generalized the mapping technique for the 138 entire probability distribution function of pitch-angle/energy jumps, but it remains to 139 be verified for electron cyclotron resonances with whistler-mode waves. 140

In this paper, we combine two approaches from (Artemyev et al., 2020; Lukin et 141 al., 2021) to construct the mapping technique that operates with the probability distri-142 bution function of pitch-angle/energy jumps for electron cyclotron resonances with whistler-143 mode waves. We also compare results from this newly developed mapping technique to 144 those from the SDE approach, which operates by a single characteristic of such prob-145 ability distribution functions of pitch-angle/energy jumps – distribution variance, which 146 dictates the diffusion rate. We examine two wave intensities: small intensity for the dif-147 fusive interaction, when SDE and mapping are expected to provide the same results, and 148 large intensity with nonlinear wave-particle interactions, when the mapping technique 149 is validated by full test particle simulations. Therefore, this paper demonstrates the ap-150 proaches to incorporate the long-term effects of quasi-linear and nonlinear wave-particle 151 interactions into global scale test-particle models. 152

The rest of the paper starts with introducing basic characteristics of electron resonant interactions with whistler-mode waves in the dipole magnetic field (see Sect. 2). Then in Sect. 3, we introduce the main property of electron ensemble dynamics – the probability distribution function of energy/pitch-angle jumps in a single resonance. This distribution is used to introduce SDE approach (in Sect. 4) and mapping technique (in Sect. 5). Results obtained from SDE and mapping approaches are compared with test

particle simulations in Sect. 6. Finally, we discuss the applicability of both methods and
 briefly summarize our conclusions in Sect. 7.

¹⁶¹ 2 Resonant electron interactions with whistler-mode waves

We examine the interaction of relativistic electrons (rest mass m_e , charge -e, speed of light c) with field-aligned whistler-mode waves moving in the dipole magnetic field $B_0(\lambda)$, where λ is the magnetic latitude. Electron dynamics in such a system can be described by the following Hamiltonian (Albert, 1993; Vainchtein et al., 2018):

$$H = \sqrt{m_e^2 c^4 + c^2 p_z^2 + 2I_x \Omega_0(\lambda) m_e c^2} + \sqrt{\frac{2I_x \Omega_0(\lambda)}{m_e c^2} \frac{eB_w(\lambda)}{k(\lambda)} \cos(\phi + \psi)}$$
(1)

where (z, p_z) and (ψ, I_x) are two pairs of conjugate variables, the field-aligned coordinate and moment, and electron gyrophase and magnetic moment. The electron cyclotron frequency $\Omega_0(\lambda)$ is defined as

$$\Omega_0(\lambda) = \Omega_{eq} \frac{\sqrt{1 + 3\sin^2(\lambda)}}{\cos^6(\lambda)} \tag{2}$$

where $\Omega_{eq} = eB_0(0)/m_ec$ is the equatorial cyclotron frequency determined by the radial distance from the Earth to the equatorial crossing of the magnetic field line, i.e., *L*shell. In the dipole field, the magnetic latitude, λ , is related to the field-aligned coordinate *z* as:

$$\frac{dz}{d\lambda} = R_E L \sqrt{1 + 3\sin^2(\lambda)} \cos(\lambda) \tag{3}$$

where R_E is the Earth radius. Note that in Hamiltonian (1), the magnetic moment, I_x , conjugate to the gyrophase, ψ , should be normalized in such a way that $I_x \Omega_0$ has a dimension of energy.

The second term in Hamiltonian (1) describes the wave contribution to the electron dynamics. The wave amplitude B_w is modeled as:

$$B_w(\lambda) = \varepsilon B_0(0) f(\lambda), \quad f(\lambda) = \begin{cases} \tanh\left(c_\lambda(\lambda - \lambda_0)\right), \ \lambda \ge \lambda_0\\ 0, \ \lambda < \lambda_0 \end{cases}$$
(4)

where ε parameter controls $B_w/B_0(0)$, function $f(\lambda)$ determines the wave latitudinal pro-165 file that agrees with the wave generation around the equator, i.e., wave amplitude growth 166 within the generation/amplification region $\Delta \lambda$, which is controlled by the value of c_{λ} : 167 $\Delta\lambda \sim 1/c_{\lambda}$, followed by saturation (see typical $B_w(\lambda)$ profiles from statistical models 168 in Agapitov et al., 2013, 2018). Note that we assume the waves only exist in one hemi-169 sphere, z > 0, because the wave field and wave propagation equations are symmetric 170 in two hemispheres $(z \rightarrow -z \text{ does not change the system equation})$. This assumption 171 allows us to simplify the calculations, because in this case the wave-particle interaction 172 occurs only during a quarter of the bounce period when the particles move northward 173 from the equator. 174

The wave phase is given by equation $\dot{\phi} = k(\lambda)\dot{z} - \omega$, where the wave frequency ω is constant and the wave number $k(\lambda)$ is determined by the cold plasma dispersion relation (Stix, 1962):

$$ck(\lambda) = \Omega_{pe}(\lambda) \left(\frac{\Omega_0(\lambda)}{\omega} - 1\right)^{-1/2}$$
(5)

The plasma frequency Ω_{pe} is given by the empirical function (Denton et al., 2006)

$$\Omega_{pe}(\lambda) = \Omega_{pe,eq} \cos^{-5/2}(\lambda) \tag{6}$$

with the equatorial values $\Omega_{pe,eq}$ given by the empirical function (Sheeley et al., 2001) $\Omega_{pe,eq}/\Omega_0(0) \approx L.$

Wave phase ϕ linearly depends on time, $\partial \phi / \partial t = \omega = const$, and thus Hamiltonian (1) has an integral of motion h (see, e.g., review by Shklyar & Matsumoto, 2009):

$$h = \sqrt{m_e^2 c^4 + c^2 p_z^2 + 2I_x \Omega_0(\lambda) m_e c^2} - \omega I_x$$
(7)

In the absence of wave perturbation, $B_w = 0$, particle energy $m_e c^2(\gamma - 1)$ and equatorial pitch-angle $\alpha_{eq} = \arcsin\left(2I_x\Omega_0(0)/m_ec^2(\gamma^2 - 1)\right)$ are conserved; here

$$\gamma = \sqrt{1 + \left(\frac{p_z}{m_e c}\right)^2 + \frac{2I_x \Omega_0(\lambda)}{m_e c^2}}$$

is the gamma factor. Wave-particle resonant interactions can change particle's energy and equatorial pitch-angle (change I_x), but due to the conservation of $h(\gamma, I_x)$ waves move electrons along a specific curve in the energy, pitch-angle space. Therefore, for a fixed value of h (i.e., when all particles have the same initial h), the wave-particle resonant interaction becomes a 1D problem, and we may just examine energy changes, whereas changes of equatorial pitch-angle (or I_x) can be determined from h = const.

To obtain basic characteristics of wave-particle resonant interactions, we integrate electron equations of motion (Hamiltonian equations) with 4th order Runge-Kutta scheme with an adaptive time step (1/20 of the local electron gyroperiod). Throughout the rest of the paper, we use the following dimensionless variables:

$$H \to Hm_e c^2, \ p_z = pm_e c, \ I_x \to I_x \frac{m_e c^2}{\Omega_{eq}}, \ t \to t/\Omega_0(0), \ z \to z \frac{c}{\Omega_{eq}}$$
 (8)

Thus, the dimensionless Hamiltonian and integral of motion h take the following forms

$$H = \sqrt{1 + p_z^2 + 2I_x \Omega_0(\lambda)} + \sqrt{2I_x \Omega_0(\lambda)} \frac{\varepsilon f(\lambda)}{k(\lambda)} \cos(\phi + \psi)$$
(9)
$$h = \sqrt{1 + p_z^2 + 2I_x \Omega_0(\lambda)} - \omega I_x$$
(10)

where $\Omega(\lambda) \to \Omega(\lambda)\Omega_0(0)$. To demonstrate the result, we use the following parameters 183 throughout: $h = 3/2, \lambda_0 = 5^{\circ}$, and $c_{\lambda} = 180/\pi$. Each integration starts from the 184 equatorial plane ($\lambda = z = 0$) and stops there after N_{res} resonant wave-particle inter-185 actions. Since waves only exist in the northern hemisphere at a fixed frequency, and prop-186 agate along magnetic field lines (i.e., resonate with electrons through the first-order cy-187 clotron resonance only), each electron bounce period corresponds to one wave-particle 188 interaction on a time scale of a quarter bounce period. Effects of multiple resonances within 189 one bounce period (e.g., due to oblique wave propagation or wave frequency variation 190 with time, see Shklyar & Matsumoto, 2009; Artemyev et al., 2021; Hsieh & Omura, 2023) 191 can be incorporated into this approach by including additional wave terms into Eq. (9). 192

Depending on the wave magnitude, there are two possible regimes of wave-particle 193 resonant interactions: diffusive scattering and nonlinear resonant interactions. Figure 194 2 shows the profiles of electron energy evolution with time for both regimes (all electrons 195 have the same initial energy and pitch-angle, but random initial gyrophases). For small 196 wave amplitudes: (a) the interaction is linear and energy evolution with time is stochas-197 tic. After each wave-particle interaction, the electron energy undergoes a small (com-198 pared to electron initial energy) positive or negative jump with almost equal probabil-199 ities to increase or decrease the energy. This process (with normalized diffusion coeffi-200 cients) can be approximated by the Wiener stochastic process, i.e., the evolution of elec-201 tron distribution function can be described by the Fokker-Planck equation or, equiva-202 lently, by stochastic differential equations. For large wave amplitudes: (b) electron dy-203 namics cannot be described with the diffusive approach. Most of the time, particle energy undergoes small negative jumps (but positive jumps are also possible, see Albert 205 et al., 2022) and there is a nonzero probability of large positive jumps, caused by par-206 ticle phase trapping. 207



Figure 2. Examples of electron energy dynamics for the system with diffusive scattering (a) and nonlinear resonant effects (b). All electrons have the same initial energy and pitch-angle, but random initial gyrophases. Energy is plotted versus number of resonant interactions (i.e., number of electron bounce periods).

²⁰⁸ 3 Probability distributions of energy jumps

To quantify variations of electron energy due to wave-particle resonant interactions, 209 we use test particle simulations and evaluate the distributions of energy jumps as a func-210 tion of initial energy E_0 , $\Delta E(E_0)$. Figure 3 shows such distributions for several initial 211 electron energies and two different magnitudes of the wave field. For each histogram, we 212 integrated trajectories of $N_p = 32768$ test particles with random initial gyrophases and 213 the same initial energy and h values. Each integration includes one bounce period (i.e., 214 a single resonant interaction). For small wave amplitudes (panels (a-d)), electron energy 215 jumps are small and randomly (but symmetrically) distributed around zero. For suffi-216 ciently high wave amplitudes (panels (e-h)), there appear nonlinear resonant effects: most 217 of the electrons lose their energy due to the phase bunching with $\Delta E < 0$, while a small 218 population of phase trapped particles (panels (g-h)) gain a significant portion of energy 219 with $\Delta E > 0$ comparable to their initial energy, E_0 . Changes of the electron pitch-angle 220 (and I_x) are directly determined by the energy changes due to the conservation of the 221 integral of motion (7). Therefore, the probability distribution of $\Delta E(E_0)$ fully charac-222 terizes the evolution of electron distribution function and can be used as a basic input 223 for the SDE approach or mapping technique. Note that for intense, but very low-coherent 224 waves, the probability distribution function of $\Delta E(E_0)$ will be symmetric relative to $\Delta E(E_0) =$ 225 0, and thus will largely resemble distributions from panels (a-d) (see Zhang et al., 2020; 226 An et al., 2022; Gan et al., 2022; Frantsuzov et al., 2023). 227

4 Stochastic differential equations

In the limit of small wave field amplitudes, the wave-particle resonant interaction is diffusive (e.g., Kennel & Engelmann, 1966; Lyons & Williams, 1984; Schulz & Lanzerotti, 1974; Allanson et al., 2022, and references therein). Note that in inhomogeneous magnetic field, these interactions are diffusive even for monochromatic waves (see Albert, 2010; Shklyar, 2021). Therefore, for such systems one can use the Fokker-Planck



Figure 3. Examples of ΔE probability distributions for systems without nonlinear resonant effects (a-d) and with nonlinear resonant effects (e-h). In panels (e,f), we show simulation results for E_0 without trapping: a small population of $\Delta E > 0$ is due to the positive phase bunching effect (see Albert et al., 2022). In panels (g,h), we show simulation results with phase trapping; the inserted panels show the expanded view of the population with large $\Delta E > 0$.

equation to describe the evolution of the electron distribution function $f(\boldsymbol{\chi})$ of the velocity vector $\boldsymbol{\chi}$:

$$\frac{\partial f(\boldsymbol{\chi},t)}{\partial t} = -\sum_{i=1}^{N} \frac{\partial}{\partial \chi_{i}} \left(\mu_{i}(\boldsymbol{\chi},t) f(\boldsymbol{\chi},t) \right) + \sum_{i=1}^{N} \sum_{j=1}^{N} \frac{\partial^{2}}{\partial \chi_{i} \partial \chi_{j}} \left(D_{ij}(\boldsymbol{\chi},t) f(\boldsymbol{\chi},t) \right)$$
(11)

where t is time, $\mu(\chi(t), t)$ is an N-dimension vector of the drift coefficient, D is an N× N matrix of diffusion coefficients (Lyons & Williams, 1984; Schulz & Lanzerotti, 1974; Albert, 2018). Instead of solving the Fokker-Planck equation, we can use the corresponding Ito stochastic differential equations to integrate trajectories of quasi-particles (Tao et al., 2008; Zheng et al., 2014):

$$\boldsymbol{\chi}(t + \Delta t) = \boldsymbol{\chi}(t) + \boldsymbol{\mu}(\boldsymbol{\chi}(t), t)\Delta t + \boldsymbol{\sigma}(\boldsymbol{\chi}(t), t)\boldsymbol{dW_t}$$
(12)

where Δt is the time step over which we calculate the change of $\boldsymbol{\chi}, \boldsymbol{\sigma}(\boldsymbol{\chi}(t), t)$ is an $N \times$ 229

N-dimension matrix related to the diffusion coefficients written in such a way that D =230 $\frac{1}{2}\sigma\sigma^T$, W_t is an N-dimension standard Wiener process; $dW_t = \sqrt{\Delta t N}$, where N is 231

a vector of standard normal random values, $N_i \sim N(0, 1)$. 232

The term *quasi-particles* means that we do not directly integrate the equations of motion, but treat the change of χ as a stochastic process and approximate it by the equation (12). As a result, two quasi-particles having equal initial conditions χ_0 may have different trajectories $\chi(t)$ (in the numerical integration of the equation (12), one can fix the seed of the pseudo random generator to preserve the sequence of random numbers and make the results repeatable). We will examine electron distributions in the energy space, and thus the Ito equation (12) can be rewritten in the following form

$$E(t + \Delta t) = E(t) + \mu_E(E(t))\Delta t + \sqrt{2D_E(E(t))}dW_t$$
(13)

This equation describes the energy evolution for fixed h given by Eq. (10), i.e., for a monochro-233

matic wave we may reduce the energy, pitch-angle evolution to the energy-only evolu-234

tion and calculate the associated pitch-angle changes from h conservation. For generic 235

wave spectra, there are three diffusion rates (energy, pitch-angle, and mixed energy-pitchangle), and thus we would need to solve a system of equations for the energy and pitchangle evolution (see detail in Tao et al., 2008). Note that if we rewrite the Fokker-Planck
equation in terms of energy, additional coefficients of variable transformation from velocity (momentum) to energy and pitch-angle (Lamé coefficients) should be added (e.g.,
Glauert & Horne, 2005), but the Ito equation will still have the same form.

The main limitation of this approach is the requirement on small energy changes ΔE for each wave-particle interaction, i.e., it is only applicable for systems without nonlinear effects of phase trapping. Equation (13) includes the drift $\mu_E(E_0)$ and bounce averaged diffusion $D_E(E_0)$ coefficients, which can be estimated using the distribution of energy jumps $\Delta E(E_0)$:

$$D_E(E_0) = \frac{1}{2\tau_b(E_0)} \left(\frac{1}{N_p} \sum_{i=1}^{N_p} \Delta(E_i)^2(E_0) - \left(\frac{1}{N_p} \sum_{i=1}^{N_p} \Delta E_i(E_0) \right)^2 \right)$$
(14)

For the drift term, we use

$$\mu_E(E_0) = \frac{dD_E(E_0)}{dE_0} \tag{15}$$

which keeps the divergence-free form of the Fokker-Planck equation (Lichtenberg & Lieber-242 man, 1983; Sinitsyn et al., 2011; Lemons, 2012; Zheng et al., 2019; Allanson et al., 2022). 243 Note that using such estimates of drift and diffusion coefficients, we implicitly assume 244 that the $\Delta E(E_0)$ distributions are symmetric relative to the mean ΔE value. Figures 245 4(a-b) show the numerically obtained ΔE distributions (black) and their fittings to sym-246 metric Gaussian distributions (this fitting outputs the variance $\sim D_E(E_0)$). However, 247 this assumption may be violated even in the case of small wave amplitudes (see Figure 248 3(c), when we can over- or underestimate the drift and diffusion coefficients. We will 249 discuss the corresponding uncertainties in Section 6. Figure 4(c) shows the drift and dif-250 fusion coefficients as a function of the electron initial energy E_0 . 251

Each electron bounce period corresponds to a single wave-particle interaction (as commented above), and thus the time step of integration Δt in the equation 13 should be set equal to $\tau_b(E_0)$. The main advantage of the SDE approach (and also of the mapping technique, which will be discussed in the Section 5), in comparison with the test particle approach, is the significant reduction of computational time for long-term simulations (see also discussions in Lukin et al., 2021): we integrate trajectories of quasiparticles with a time step equal to the bounce period, considering only the effects of waveparticle interactions and do not trace particles during adiabatic paths of their motion. So at each step of integration, we recalculate the electron energy as

$$E_{i+1} = E_i + \mu_E(E_i)\tau_b(E_i) + \sqrt{2D_E(E_i)\tau_b(E_i)}N_i$$

where $N_i \sim N(0, 1)$ is the standard normal random number.

Panels (d,e) in Figure 4 show examples of the electron energy profiles calculated
by direct integration of the Hamiltonian equations or using the SDE approach. Particles having equal initial conditions will have different trajectories from these two approaches,
due to randomness of resonant interactions, but statistical properties of the evolution
of the electron ensemble should be the same. We have verified this property by a set of
simulated evolution of the electron ensembles (not shown).

²⁵⁹ 5 Mapping technique

For high wave amplitudes, the SDE approach is no longer applicable, because of the nonlinear effects of wave-particle interactions. In this case, the Wiener stochastic process cannot describe the evolution of electron energy as there is a finite probability of



Figure 4. Panels (a,b) show ΔE distributions (in black), obtained after a single wave-particle interaction, and Gaussian distributions with the same variance (in red). Panel (c) shows the energy diffusion rate and drift term versus initial energy. Panels (d,e) show examples of ten trajectories of long-term electron energy dynamics (~ 300 resonances) for a system without non-linear resonant effects.

large energy jumps caused by the phase trapping. For such systems, the Ito SDE can
be generalized by introducing a new stochastic process accounting for the phase trapping and phase bunching. This process can be represented by a series of mapping functions depending on electron energy (the changes of pitch-angle are related to energy changes
through the integral of motion (7)).

Figure 5(a) shows the distribution of energy jumps for the wave amplitude $\varepsilon = 10^{-3}$ 268 and initial electron energy $E_0 = 257$ keV. For this particular energy, there is no elec-269 tron phase trapping: the resonant latitude for this energy and h (which determines the 270 equatorial pitch-angle) corresponds to zero probability of electron trapping, because wave 271 intensity increases slower along the resonant trajectory than the background magnetic 272 field inhomogeneity (see detailed equations determining the trapping probability in the 273 Appendix of Vainchtein et al., 2018, and in references therein). Hence the procedure to 274 construct the mapping function is straightforward: using this distribution, one can cal-275 culate the cumulative function of energy jumps $F(\Delta E, E_0) \in [0, 1]$ (right vertical axis 276 in Figure 5(a)) and then use the inverse function $\Delta E(U) = F^{-1}(U, E_0), U \in [0, 1]$ as 277 the generator of electron energy jumps for each wave-particle interaction. 278

Figure 5(b) shows the distribution of energy jumps for an initial electron energy of $E_0 = 350$ keV. There is a small probability of electron phase trapping in this case, thus we can divide the ΔE distribution into bunching $(|\Delta E|/E_0 \ll 1)$ and trapping $(\Delta E/E_0 \sim$ 1) parts, and then calculate corresponding cumulative functions: $F_b(\Delta E, E_0)$ and $F_t(\Delta E, E_0)$. Note that this separation of ΔE distribution into two parts is not necessary, but it simplifies the calculations by allowing a linear interpolation for the cumulative function. There is a gap of ΔE between two parts of ΔE distribution, i.e., for the case shown in Figure 5(b) the electron energy cannot change by the value between ~ 4 and ~ 95 keV (prohibited values of ΔE in this case). If we would not separate the ΔE distribution into two parts, this ΔE gap will require a separate treatment. Using trapping ΔE distributions, we may estimate the probability of electron trapping $p_{trap}(E_0)$ (shown in Figure 5(c)) as a function of the initial electron energy:

$$p_{trap}(E_0) = \frac{N(\Delta E(E_0)/E_0 \sim 1)}{N_p}$$
(16)

where N_p is the total number of particles used to construct the $\Delta E(E_0)$ distribution and $N(\Delta E(E_0)/E_0 \sim 1)$ is the number of trapped particles.

We use the subscript b for the bunching part of the $\Delta E(E_0)$ distribution and also for the entire $\Delta E(E_0)$ distribution if the probability of trapping is equal to zero. Then the generalization of the Ito SDE is straightforward: we can replace the Wiener process in equation (13) with the constructed mapping functions. At each integration step, we generate two uniform random numbers $u_1, u_2 \in U(0, 1)$ and recalculate electron energy as

$$E_{i+1} = E_i + \begin{cases} F_t^{-1}(u_2, E_i), & u_1 \le p_{trap}(E_i) \\ F_b^{-1}(u_2, E_i), & u_1 > p_{trap}(E_i) \end{cases}$$
(17)

Note that the gap between ΔE distributions due to phase trapping and bunching 281 (see Figure 5(b)) depends on system parameters (mostly on the wave field model) and, 282 e.g., for the system with small wave-packets, the energy of phase-trapped electrons could 283 not be far away from the initial energy (e.g., Omura et al., 2015). In this case, there is 284 no need to divide the distributions into *bunching* and *trapping* parts and thus only one 285 cumulative function, $F(\Delta E, E_0)$, needs to be constructed. In this case, the computation 286 scheme slightly simplifies: at each iteration one needs to calculate a single, uniform ran-287 dom number $u \in U(0,1)$ and the energy change can be calculated in the same man-288 ner: $E_{i+1} = E_i + F^{-1}(u, E_i)$. 289

Figures 5(d,e) show several profiles of electron energy as a function of the number of wave-particle resonances, calculated by integration of the test particle trajectories and



Figure 5. Panels (a,b) show ΔE distributions and the corresponding cumulative probability distribution function (only on panel (a)). Panel (c) shows the probability of electron phase trapping versus the initial energy. Panels (d,e) show examples of ten trajectories of long-term electron energy dynamics (~ 300 resonances) for a system with nonlinear resonant effects.

using the mapping technique, respectively. Both approaches show very similar electron energy dynamics: long-duration electron drift to smaller energy due to the phase bunching and rare large jumps to higher energy due to the phase trapping. Note that for both SDE and mapping techniques, we still need to use test particles to calculate the initial distributions of $\Delta E(E_0)$, but having these distributions (requiring statistics of single waveparticle interactions), we can use the simplified integration scheme with a time step equal to the bounce period.

²⁹⁹ 6 Method validation

For small wave amplitudes, we can apply all three methods (test particles, SDE, 300 and mapping) to simulate the evolution of the electron distribution function, and these 301 three methods are expected to give the same results. The test particles approach is ex-302 pected to be more precise, because it does not rely on the constructed ΔE distribution 303 and is based on the full set of equations of motion. The main advantage of SDE and map-304 ping techniques is their computational efficiency in long-term simulations, so they can 305 be less accurate, but should still describe the main features of the evolution of electron 306 distributions and their results should statistically repeat those from the test particles ap-307 proach. Figure 6 (left panels) shows the evolution of the electron distribution function 308 for a small wave amplitude ($\varepsilon = 10^{-4}$) at four time instants. Hereinafter $N_n = 32768$ 309 test particles are used to compute the changes of the distribution functions for all men-310 tioned approaches. Without nonlinear resonant effects, both SDE and mapping technique 311 show results that are consistent with the test particle simulation. In this case, the evo-312 lution is diffusive (as expected for quasi-linear theory) and shows a spread of the initially 313

localized electron phase space density peak. The difference between SDE and the test 314 particle simulation, most clearly seen around $E \sim 420$ keV, is due to the overestima-315 tion of the diffusion coefficients. We evaluate diffusion coefficients as a half of the vari-316 ance of ΔE distributions, and thus we assume that ΔE distributions are symmetric rel-317 ative to the mean value. However, even in the case of low-amplitude waves (see, e.g., Fig-318 ure 3(c)) this assumption may not work, which will result in an overestimation of the 319 diffusion rate. The mapping technique does not require any assumptions about ΔE dis-320 tributions, and thus it performs better even in the case of low-amplitude waves. 321

Figure 6 (right panels) shows the evolution of the electron distribution function for 322 a large wave amplitude ($\varepsilon = 10^{-3}$) at four time instants. For such intense waves, the 323 SDE approach becomes inapplicable, but we can still compare results of test particle sim-324 ulations and the mapping technique. The mapping technique accounts for nonlinear res-325 onant effects (e.g., phase trapping) and describes well the evolution of electron distri-326 butions. After several wave-particle resonant interactions (see top right panel of Figure 327 6), the main electron population propagates to lower energies due to the phase bunch-328 ing, while a small population becomes trapped by waves and gains energy. During the 329 drift of the main population to the smaller energies, the probability of particle trapping 330 increases (see Figure 5(c)) and more particles become trapped and accelerated. Accel-331 erated particles appear in the resonant latitudes where no more phase trapping is pos-332 sible, and thus these particles start losing their energy due to the phase bunching. Around 333 the time when the main population (at the initial peak of electron phase space density) 334 reaches the left boundary of the allowed energies, the processes of phase bunching and 335 phase trapping statistically compensate each other. This results in formation of a plateau 336 in the distribution function (see the bottom right panel in Figure 6). Such an evolution 337 of the electron distribution is consistent with theoretical predictions for the system with 338 multiple nonlinear resonances (Artemyev et al., 2019). 339

The main uncertainty of the mapping technique arises at the edges of the simula-340 tion domain due to the finite grid size (discretization) in the ΔE distribution. In this 341 approach, we treat the electron energy change as a probabilistic process and in Eqs. (13) 342 and (17), electrons can reach the energy $E < E_{min}$ outside of the simulation domain. 343 In the subsequent calculations, therefore, we will use the mapping functions correspond-344 ing to the energy E_{min} to calculate electron energy change. This underestimates the prob-345 ability of positive and overestimate probability of negative energy jumps, so that par-346 ticles can stay at the edges of the energy grid for a long time. The SDE approach also 347 suffers from this boundary effect. This problem can be eliminated by introducing bound-348 ary conditions, e.g., reflective boundaries, or by normalizing the ΔE distribution around 349 boundaries (see discussions in the Appendix of Artemyev et al., 2021). 350

³⁵¹ 7 Discussion and conclusions

In this study we compare two approaches that incorporate the wave-particle res-352 onant effects into test particle simulations: SDE approach and mapping technique. Both 353 approaches simplify the characterization of wave-particle interactions and reduce reso-354 nant effects to a ΔE distribution of energy jumps during a single interaction; in partic-355 ular, SDE further simplifies this description and operates only by the second moment 356 (variance) of this distribution. The comparison shows that these two approaches pro-357 vide the same results for the system with low-amplitude waves, whereas electron non-358 linear resonant interactions with intense waves may be only described well by the map-359 ping technique. Note that the diffusion approximation is not only applicable to low in-360 tensity waves, but also to systems with very intense, low-coherent waves where the res-361 onance overlapping results in destruction of nonlinear effects (Tao et al., 2013; Zhang 362 et al., 2020; An et al., 2022; Gan et al., 2022; Frantsuzov et al., 2023). Let us discuss ad-363 vantages and limitations of this technique. 364



Figure 6. Evolution of the electron energy distribution for a systems without nonlinear resonant effects (left panels) and with nonlinear resonant effects (right panels). Grey color shows the initial distribution, black color shows test particle simulation results, red color shows results obtained with SDE, and blue color shows results for the mapping technique. Time (in seconds) is calculated under the assumption of a single resonant interaction per bounce period, $\tau_b(E)$, where τ_b is evaluated at *L*-shell = 6 and for equatorial pitch-angles derived from Eq. (7).

The mapping technique is based on ΔE distributions, which for fixed system pa-365 rameters depends only on the initial electron energy E_0 , i.e., we deal with 2D distribu-366 tions of energy (or pitch-angle) jumps, $F(\Delta E, E_0)$, which are used as described in Sec-367 tion 5. These distributions can be determined with any required accuracy from a set of 368 short-term test particle simulations. However, in realistic space plasma systems, we deal 369 with some ensemble of waves that can be described by the distribution of wave ampli-370 tudes and frequencies, $\mathcal{P}_w(B_w, \omega)$; for reasonable discretization levels and available sta-371 tistical wave datasets, this wave distribution usually consists of $\sim 10^2 - 10^3$ different 372 pairs of (B_w, ω) (see, e.g., Artemyev, Zhang, et al., 2022; Zhang et al., 2022). Therefore, 373 for the mapping technique, we would need to evaluate $10^2 - 10^3$ realizations of 2D $F(\Delta E, E_0)$ 374 distributions. Additional system dimensions can be introduced due to the dependence 375 of $\mathcal{P}_w(B_w, \omega)$ on the geomagnetic activity and geophysical coordinates, (MLT, L-shell). 376 Therefore, although the mapping technique essentially reduces computations relative to 377 the full test particle simulations, this approach requires significant resources for simu-378 lation of electron dynamics during long-term global events (where wave and background 379 characteristics can vary significantly), e.g., geomagnetic storms. More suitable applica-380 tion of the mapping technique is simulations of localized (spatially and temporally) events, 381 like plasma sheet injections (Artemyev, Neishtadt, & Angelopoulos, 2022) or strong pre-382 cipitation bursts (Artemyev, Zhang, et al., 2022; Zhang et al., 2022). For global simu-383 lations with SDE, which substitute 2D $F(\Delta E, E_0)$ distributions by 1D diffusion coeffi-384 cients $D_{EE}(E_0)$, should be much more realistic, although this approach does not account 385 for nonlinear resonant effects. 386

Both the SDE approach and mapping technique assume the evaluation of $F(\Delta E, E_0)$ 387 distributions before simulating the electron dynamics, and thus such distributions are 388 usually evaluated for a prescribed background magnetic field. This simplification may 389 work for the inner magnetosphere, where the background dipole field does not vary too 390 much (see Orlova & Shprits, 2010; Ni et al., 2011, for discussions on when this assump-391 tion does not work well), but cannot be well justified for plasma injections characterized 392 by rapid, significant variations of the magnetic field configuration (see discussion in Ashour-393 Abdalla et al., 2013; Sorathia et al., 2018; Birn et al., 2022). The background magnetic 394 field configuration determines the resonant condition and thus should control the effi-395 ciency of electron scattering by waves. In principle, the effect of the magnetic field re-396 configuration can be included into SDE and mapping approaches, but this would require 397 the evaluation of $F(\Delta E, E_0)$ distributions for multiple magnetic field configurations, which 398 is usually unlikely with available computational resources. A possible solution will be to analytically evaluate $F(\Delta E, E_0)$ distributions (e.g., Vainchtein et al., 2018; Artemyev 400 et al., 2021), but this solution requires more developed theoretical models of wave-particle 401 resonant interactions including effects of wave-field deviations from a simple plane wave 402 model (see discussions in Mourenas et al., 2018; Artemyev et al., 2023). So far such effects have been evaluated (e.g., Tao et al., 2011; Zhang et al., 2020; Allanson et al., 2021; 404 Gan et al., 2022; An et al., 2022) and incorporated into $F(\Delta E, E_0)$ distributions (e.g., 405 Kubota & Omura, 2018; Hsieh et al., 2020, 2022) only via numerical integration of a large 406 test particle ensemble. 407

Both the SDE approach and mapping technique are based on numerical evaluations 408 of the probability distribution function of energy jumps, $F(\Delta E, E_0)$. Although we have 409 adopted the plane wave approximation in this study, the procedure of $F(\Delta E, E_0)$ eval-410 uations is independent of such approximations and F can be calculated for more real-411 istic modes of wave-packets (see observations and simulations in Zhang et al., 2018, 2021) 412 This generalization for the finite wave-packet size is quite important for constraining the 413 efficiency of nonlinear resonant effects (see, e.g., Kubota & Omura, 2018; Zhang et al., 414 2020; An et al., 2022). Therefore, in the next step, one would need to incorporate real-415 istic distributions of whistler-mode wave-packet sizes. 416

417 Acknowledgments

418 Work of A.S.L., A.V.A., X.-J.Z. is supported by NASA grants 80NSSC23K0089, 80NSSC23K0108,

and 80NSSC21K0729. O.A. would like to acknowledge financial support from the the Uni-

versity of Birmingham, the University of Exeter, and also from the United Kingdom Re-

search and Innovation (UKRI) Natural Environment Research Council (NERC) Inde-

⁴²² pendent Research Fellowship NE/V013963/1 and NE/V013963/2

423 Open Research

⁴²⁴ No data sets were used in this work.

425 References

437

442

448

449

Agapitov, O. V., Artemyev, A., Krasnoselskikh, V., Khotyaintsev, Y. V., Moure-
nas, D., Breuillard, H., Rolland, G. (2013, June). Statistics of whistler
mode waves in the outer radiation belt: Cluster STAFF-SA measurements. J .
Geophys. Res., 118, 3407-3420. doi: 10.1002/jgra.50312
Agapitov, O. V., Artemyev, A., Mourenas, D., Krasnoselskikh, V., Bonnell, J., Le
Contel, O., Angelopoulos, V. (2014). The quasi-electrostatic mode of
chorus waves and electron nonlinear acceleration. J. Geophys. Res., 119,
1606–1626. doi: 10.1002/2013JA019223
Agapitov, O. V., Artemyev, A. V., Mourenas, D., Mozer, F. S., & Krasnoselskikh,
V. (2015, December). Nonlinear local parallel acceleration of electrons through
Landau trapping by oblique whistler mode waves in the outer radiation belt.

Geophys. Res. Lett., 42, 10. doi: 10.1002/2015GL066887

- Agapitov, O. V., Mourenas, D., Artemyev, A. V., Mozer, F. S., Hospodarsky, G.,
 Bonnell, J., & Krasnoselskikh, V. (2018, January). Synthetic Empirical
 Chorus Wave Model From Combined Van Allen Probes and Cluster Statistics. Journal of Geophysical Research (Space Physics), 123(1), 297-314. doi:
 - 10.1002/2017JA024843
- Albert, J. M. (1993, August). Cyclotron resonance in an inhomogeneous magnetic field. *Physics of Fluids B*, 5, 2744-2750. doi: 10.1063/1.860715
- 445Albert, J. M. (2001, May).Comparison of pitch angle diffusion by turbulent and
monochromatic whistler waves.446monochromatic whistler waves.J. Geophys. Res., 106, 8477-8482.447.1029/2000JA000304
 - Albert, J. M. (2010, March). Diffusion by one wave and by many waves. J. Geophys. Res., 115, 0. doi: 10.1029/2009JA014732
- Albert, J. M. (2018, October). Diagonalization of diffusion equations in two and
 three dimensions. Journal of Atmospheric and Solar-Terrestrial Physics, 177,
 202-207. doi: 10.1016/j.jastp.2017.08.008
- Albert, J. M., Artemyev, A., Li, W., Gan, L., & Ma, Q. (2022, August). Analytical results for phase bunching in the pendulum model of wave-particle interactions. *Frontiers in Astronomy and Space Sciences*, 9, 971358. doi: 10.3389/fspas.2022.971358
- Albert, J. M., Tao, X., & Bortnik, J. (2013). Aspects of Nonlinear Wave-Particle Interactions. In D. Summers, I. U. Mann, D. N. Baker, & M. Schulz (Eds.), Dynamics of the earth's radiation belts and inner magnetosphere. doi: 10.1029/2012GM001324
- Alho, M., Battarbee, M., Pfau-Kempf, Y., Khotyaintsev, Y. V., Nakamura, R., Cozzani, G., ... Palmroth, M. (2022, July). Electron Signatures of Reconnection in a Global eVlasiator Simulation. *Geophys. Res. Lett.*, 49(14), e98329. doi: 10.1029/2022GL098329
- Allanson, O., Thomas, E., Watt, C. E. J., & Neukirch, T. (2022). Weak Tur ⁴⁶⁵ bulence and Quasilinear Diffusion for Relativistic Wave-Particle Inter-

467	actions Via a Markov Approach. Frontiers in Physics, 8:805699. doi:
468	10.3389/fspas.2021.805699
469	Allanson, O., Watt, C. E. J., Allison, H. J., & Ratcliffe, H. (2021, May). Electron
470	Diffusion and Advection During Nonlinear Interactions With Whistler Mode
471	Waves. Journal of Geophysical Research (Space Physics), 126(5), e28793. doi:
472	10.1029/2020JA028793
473	An, Z., Wu, Y., & Tao, X. (2022, February). Electron Dynamics in a Chorus Wave
474	Field Generated From Particle-In-Cell Simulations. Geophys. Res. Lett.,
475	49(3), e97778, doi: 10.1029/2022GL097778
476	Andronov, A. A., & Trakhtengerts, V. Y. (1964). Kinetic instability of the Earth's
477	outer radiation belt. Geomagnetism and Aeronomy, 4, 233-242.
478	Angelopoulos, V., McFadden, J. P., Larson, D., Carlson, C. W., Mende, S. B., Frey,
479	H Kepko, L. (2008, August). Tail Reconnection Triggering Substorm
480	Onset. Science, 321, 931-935, doi: 10.1126/science.1160495
481	Artemyey, A. V., Agapitov, O., Mourenas, D., Krasnoselskikh, V., Shastun, V., &
482	Mozer, F. (2016, April). Oblique Whistler-Mode Waves in the Earth's Inner
483	Magnetosphere: Energy Distribution, Origins, and Role in Radiation Belt Dy-
484	namics. Space Sci. Rev., 200(1-4), 261-355, doi: 10.1007/s11214-016-0252-5
485	Artemyev A V Albert J M Neishtadt A I & Mourenas D (2023 January)
485	The effect of wave frequency drift on the electron nonlinear resonant inter-
487	action with whistler-mode waves $Physics of Plasmas 30(1) 012901$ doi:
488	10.1063/5.0131297
489	Artemyey, A. V., Neishtadt, A. L. & Angelopoulos, V. (2022, April). On the Role
490	of Whistler-Mode Waves in Electron Interaction With Dipolarizing Flux Bun-
491	dles. Journal of Geophysical Research (Space Physics), 127(4), e30265, doi:
492	10.1029/2022JA030265
403	Artemvev A V Neishtadt A I Vainchtein D L Vasiliev A A Vasko I Y
494	& Zelenvi, L. M. (2018, December). Trapping (capture) into resonance and
495	scattering on resonance: Summary of results for space plasma systems. <i>Com</i> -
496	munications in Nonlinear Science and Numerical Simulations, 65, 111-160.
497	doi: 10.1016/j.cnsns.2018.05.004
498	Artemyey, A. V., Neishtadt, A. L. & Vasiliey, A. A. (2019, Jun). Kinetic
499	equation for nonlinear wave-particle interaction: Solution properties and
500	asymptotic dynamics. <i>Physica D Nonlinear Phenomena</i> , 393, 1-8. doi:
501	10.1016/j.physd.2018.12.007
502	Artemyev, A. V., Neishtadt, A. I., & Vasiliev, A. A. (2020, April). Mapping for
503	nonlinear electron interaction with whistler-mode waves. <i>Physics of Plasmas</i> .
504	27(4), 042902. doi: 10.1063/1.5144477
505	Artemyev, A. V., Neishtadt, A. I., Vasiliev, A. A., & Mourenas, D. (2016, Septem-
506	ber). Kinetic equation for nonlinear resonant wave-particle interaction. <i>Physics</i>
507	of Plasmas, 23(9), 090701. doi: 10.1063/1.4962526
508	Artemyev, A. V., Neishtadt, A. I., Vasiliev, A. A., & Mourenas, D. (2018). Long-
509	term evolution of electron distribution function due to nonlinear resonant
510	interaction with whistler mode waves. Journal of Plasma Physics, 84,
511	905840206. doi: 10.1017/S0022377818000260
512	Artemyev, A. V., Neishtadt, A. I., Vasiliev, A. A., Zhang, XJ., Mourenas, D.,
513	& Vainchtein, D. (2021, March). Long-term dynamics driven by res-
514	onant wave-particle interactions: from Hamiltonian resonance theory to
515	phase space mapping. Journal of Plasma Physics, 87(2), 835870201. doi:
516	10.1017/S0022377821000246
517	Artemyev, A. V., Zhang, X. J., Zou, Y., Mourenas, D., Angelopoulos, V.,
518	Vainchtein, D., Wilkins, C. (2022, June). On the Nature of Intense Sub-
519	Relativistic Electron Precipitation. Journal of Geophysical Research (Space
520	<i>Physics</i>), 127(6), e30571. doi: 10.1029/2022JA030571
521	Ashour-Abdalla, M., Bosqued, J. M., El-Alaoui, M., Peroomian, V., Zelenyi, L. M.,

 plasma sheet boundary layer ion structures observed by Cluster. J. Geophy Res., 110, A12221. doi: 10.1029/2005JA011183 Ashour-Abdalla, M., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Richard, R., Hwang, KJ. (2011, April). Observations and simulatio of non-local acceleration of electrons in magnetotail magnetic reconnection events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M. & Runov, A. (2022, June). Electron Anisotropies in Magnetot: Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic simulation fields. Physics of Plasmas, 11, 1825-1833. d 10.1063/1.1704641 Cattell, C. A.,	 boundary layer ion structures observed by Cluster. J. Geophys. 12221. doi: 10.1029/2005JA011183 A., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Hwang, KJ. (2011, April). Observations and simulations acceleration of electrons in magnetotail magnetic reconnection re Physics, 7, 360-365. doi: 10.1038/nphys1903 A., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. Geophys. Res. Lett., 40(15), 3787-3792. doi: 50635 dkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, , June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019788 , & Hesse, M. (2015, September). Energetic ions in dipolarization leophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 14-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be (1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 tt, R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, 91, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys.	522	Walker, R. J., & Wright, J. (2005, December). A stochastic sea: The source of
 Res., 110, A12221. doi: 10.1029/2005JA011183 Ashour-Abdalla, M., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Richard, R., Hwang, KJ. (2011, April). Observations and simulatio of non-local acceleration of electrons in magnetotail magnetic reconnection events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/9JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail:	 12221. doi: 10.1029/2005JA011183 I., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Hwang, KJ. (2011, April). Observations and simulations acceleration of electrons in magnetotail magnetic reconnection <i>re Physics</i>, 7, 360-365. doi: 10.1038/nphys1903 A., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. <i>Geophys. Res. Lett.</i>, 40(15), 3787-3792. doi: 50635 ckinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, J. June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. (Fspas.2022.908730) , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research (cs), 119(5), 3604-3616. doi: 10.1002/2015JA021372 , & Hesse, M. (2015, September). Energetic ions in dipolarization Reophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Kesse, M. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 42, 7273-7281. doi: GGL065655 giton, S. R., Longley, W. J., Aldhurais, S. A., Ala	523	plasma sheet boundary layer ion structures observed by Cluster. J. Geophys.
 Ashour-Abdalla, M., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Richard, R., Hwang, KJ. (2011, April). Observations and simulatio of non-local acceleration of electrons in magnetotail magnetic reconnection events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolarization events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during disper sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., vo	 I. El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D., Hwang, KJ. (2011, April). Observations and simulations acceleration of electrons in magnetotail magnetic reconnection <i>re Physics</i>, 7, 360-365. doi: 10.1038/nphys1903 A., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. <i>Geophys. Res. Lett.</i>, 40(15), 3787-3792. doi: 50635 dkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /rs. Kesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization <i>Feophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 , & Klou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.102/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September	524	Res., 110, A12221. doi: 10.1029/2005JA011183
 Richard, R., Hwang, KJ. (2011, April). Observations and simulatio of non-local acceleration of electrons in magnetotail magnetic reconnection events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2015JA01738 Birn, J., Runov, A., & Hesse, M. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic ismulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett.,	 Hwang, KJ. (2011, April). Observations and simulations acceleration of electrons in magnetotail magnetic reconnection <i>re Physics</i>, 7, 360-365. doi: 10.1038/nphys1903 A., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. <i>Geophys. Res. Lett.</i>, 40(15), 3787-3792. doi: 50635 Kdinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Reophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 114-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 004641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, 31, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007EL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuencey whi	525	Ashour-Abdalla, M., El-Alaoui, M., Goldstein, M. L., Zhou, M., Schriver, D.,
 of non-local acceleration of electrons in magnetotail magnetic reconnection events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispe sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic simulation fields. Physics of Plasmas, 11, 1825-1833. du 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, Janu	 acceleration of electrons in magnetotail magnetic reconnection <i>re Physics</i>, 7, 360-365. doi: 10.1038/nphys1903 <i>A.</i>, Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. <i>Geophys. Res. Lett.</i>, 40(15), 3787-3792. doi: 30635 akinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, J. June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 ak Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. <i>Frontiers in Astronomy and Space Sciences</i>, 9, 908730. Afspas.2022.908730 ak Hesse, M. (2014, May). Energetic electrons in dipolariza- Spatial properties and anisotropy. <i>Journal of Geophysical Research</i> <i>ics</i>), 119(5), 3604-3616. doi: 10.1002/2013JA019738 ak Hesse, M. (2015, September). Energetic ions in dipolarization <i>Geophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 ak Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. <i>J. Geophys.</i> 114-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- (1997, February). Characteristic plasma properties during disper- torm injections at geosynchronous orbit. <i>J. Geophys. Res.</i>, 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magne- mic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. doi: 04641 t, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusu- uency whistler mode waves observed in association with moderate rms: Statis	526	Richard, R., Hwang, KJ. (2011, April). Observations and simulations
 events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolarization events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during dispotsionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/6JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic simulation fields. Physics of Plasmas, 1	 re Physics, 7, 360-365. doi: 10.1038/nphys1903 I., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. Geophys. Res. Lett., 40(15), 3787-3792. doi: 50635 kdinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, J. June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. , & Russe, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unustuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 6GL065565 gton, S. R., Longley, W. J., Aldhurais, S. A.,	527	of non-local acceleration of electrons in magnetotail magnetic reconnection
 Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstei M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during disposionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Ge	 A., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein, hou, M. (2013, August). Direct auroral precipitation from the during substorms. Geophys. Res. Lett., 40(15), 3787-3792. doi: 50635 ckinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753., & Runov, A. (2022, June). Electron Anisotropies in Magnetotail in Events. Frontiers in Astronomy and Space Sciences, 9, 908730. //spas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research 'cs), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization 'cophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in ne events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, 21, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unustuency whistler mode waves observed in association with moderate trms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 geton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). S	528	events. Nature Physics, 7, 360-365. doi: 10.1038/nphys1903
 M. L., Zhou, M. (2013, August). Direct auroral precipitation from t magnetotail during substorms. <i>Geophys. Res. Lett.</i>, 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. <i>J. Geophys. Res.</i>, 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. <i>Frontiers in Astronomy and Space Sciences</i>, 9, 90875 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. <i>Journal of Geophysical Resear</i> <i>(Space Physics)</i>, 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati events. <i>J. Geophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. <i>J. Geophy</i> <i>Res.</i>, 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. <i>J. Geophys. Res.</i>, 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009	 hou, M. (2013, August). Direct auroral precipitation from the during substorms. Geophys. Res. Lett., 40(15), 3787-3792. doi: 50635 kkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. (fspas.2022.908730) , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research (cs), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization <i>Peophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, 0i: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 rt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuencery whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: GiL065565 gton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle fr	529	Ashour-Abdalla, M., Schriver, D., Alaoui, M. E., Richard, R., Walker, R., Goldstein,
 magnetotail during substorms. Geophys. Res. Lett., 40(15), 3787-3792. d 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90875 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. d 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kur	 during substorms. Geophys. Res. Lett., 40(15), 3787-3792. doi: 50635 ckinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, J., June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 ., & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. ., & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 ., & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 ., & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/95JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t. J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 6GL065565 ugton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 <	530	M. L., Zhou, M. (2013, August). Direct auroral precipitation from the
 10.1002/grl.50635 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 9087; doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus all	 50635 kkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. //spas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization leophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 114-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t. J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: IGL055565 ugton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nmell, J. W., Klet	531	magnetotail during substorms. Geophys. Res. Lett., $40(15)$, 3787-3792. doi:
 Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, R. L. (1996, June). Neutral line model of substorms: Past results and prese view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90875 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of uus ally low frequency whistler mode wav	 kkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron, June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 "& Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 "& Hesse, M. (2014, May). Energetic electrons in dipolariza- Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 "& Hesse, M. (2015, September). Energetic ions in dipolarization <i>Peophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 "& Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 "M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- (1997, February). Characteristic plasma properties during disper- torm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 "M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magne- mic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, 31, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusu- uency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 geton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nmell, J. W., Clausen, L., & Angelopoulos,	532	$10.1002/{ m grl}.50635$
 R. L. (1996, June). Neutral line model of substorms: Past results and preserview. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90875 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolarization events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophys. Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during disposionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 0.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally by frequency whistler mode waves observed in association with modarst 	 June). Neutral line model of substorms: Past results and present ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 , & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of nuusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 10.10389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). port by kinetic-scale electromagnetic waves in fast plasma sheet sophys. Res., 117, 9022. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere.	533	Baker, D. N., Pulkkinen, T. I., Angelopoulos, V., Baumjohann, W., & McPherron,
 view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot. Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolarization events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarization events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during disposionless substorm injections at geosynchronous orbit. J. Geophys. Res., 102309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitud whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally by frequency whistler mode waves observed in association with moderstice of the probes observations of unus ally by frequency whistler mode waves observation setteriation doi: 10.1029/20	 ophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753 ., & Runov, A. (2022, June). Electron Anisotropies in Magnetotail on Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 ., & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 ., & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 ., & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 114-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 tt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ugton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). port by kinetic-scale electromagnetic waves in fast plasma sheet <i>sophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA01786	534	R. L. (1996, June). Neutral line model of substorms: Past results and present
 Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetot Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90873 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizativ events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with mederat 	 "& Runov, A. (2022, June). Electron Anisotropies in Magnetotail m Events. Frontiers in Astronomy and Space Sciences, 9, 908730. //spas.2022.908730 "& Hesse, M. (2014, May). Energetic electrons in dipolariza- Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 "& Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 "& Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 "M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- (1997, February). Characteristic plasma properties during disper- torm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 "M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magne- mic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 t, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusu- uency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). .port by kinetic-scale electromagnetic waves in fast plasma sheet <i>sphys. Res., 117</i>, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wyg	535	view. J. Geophys. Res., 101, 12975-13010. doi: 10.1029/95JA03753
 Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 90875 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolarization events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophys. Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during disposionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with mederation sets. 	 n Events. Frontiers in Astronomy and Space Sciences, 9, 908730. /fspas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 ti, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet sphys. Res., 117, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequen	536	Birn, J., Hesse, M., & Runov, A. (2022, June). Electron Anisotropies in Magnetotail
 doi: 10.3389/fspas.2022.908730 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispe- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kuurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat ally low frequency whistler mode waves observed in association with moderat 	 /fspas.2022.908730 , & Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ugton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space doi: 10.3389/fspas.2023.1239160 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021690 	537	Dipolarization Events. Frontiers in Astronomy and Space Sciences, 9, 908730.
 Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariz tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizati- events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat ally low frequency whistler mode waves observed in association with moderaters 	 "& Hesse, M. (2014, May). Energetic electrons in dipolariza-Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 "& Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 "& Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 "M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 "M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space doi: 10.3389/fspas.2023.1239160 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner Magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021690 	538	doi: 10.3389/fspas.2022.908730
 tion events: Spatial properties and anisotropy. Journal of Geophysical Resear (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 Spatial properties and anisotropy. Journal of Geophysical Research ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization <i>Peophys. Res.</i>, 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- (1997, February). Characteristic plasma properties during disper- torm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magne- mic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 M. F., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusu- uency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet vophys. Res., 117, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021600 	539	Birn, J., Runov, A., & Hesse, M. (2014, May). Energetic electrons in dipolariza-
 (Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarizatio events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophys. Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during disposition substorm injections at geosynchronous orbit. J. Geophys. Res., 100 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitut whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderation with moderation with moderation with moderation with moderation probes observations of unus ally low frequency whistler mode waves observed in association with moderation with moderation probes observed in association with moderation with moderation with moderation with moderation probes observed in association with moderation with moderation probes observed in association with moderation with moderation with moderation probes observed in association with moderation probes observations of unus ally low frequency whistler mode waves observed	 ics), 119(5), 3604-3616. doi: 10.1002/2013JA019738 , & Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 geton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet iophys. Res., 117, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021690 	540	tion events: Spatial properties and anisotropy. Journal of Geophysical Research
 Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarization events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophys. Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Bellian, R. D. (1997, February). Characteristic plasma properties during disposition substorm injections at geosynchronous orbit. J. Geophys. Res., 100 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitum whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unust ally low frequency whistler mode waves observed in association with moderation and produced and probes observations of unust ally low frequency whistler mode waves observed in association with moderation with moderation and probes observations of unust ally low frequency whistler mode waves observed in association with moderation and probes observations of unust ally low frequency whistler mode waves observed in association with moderation with moderation with moderation with moderation with moderation with moderation waves observed in association with moderation with moderation waves observed in association with moderation waves observed in association with moderation waves observed in association with moderatio	 "& Hesse, M. (2015, September). Energetic ions in dipolarization Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 104-8025. doi: 10.1002/2017JA024230 "M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- (1997, February). Characteristic plasma properties during disper- torm injections at geosynchronous orbit. J. Geophys. Res., 102, oi: 10.1029/96JA02870 "M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magne- mic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusu- uency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 geton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>ophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021690 	541	(Space Physics), 119(5), 3604-3616. doi: 10.1002/2013JA019738
 events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispose sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitum whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372 , & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, doi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 at, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). port by kinetic-scale electromagnetic waves in fast plasma sheet <i>sophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 nnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021690 	542	Birn, J., Runov, A., & Hesse, M. (2015, September). Energetic ions in dipolarization
 Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions dipolarization events: Distributions in the central plasma sheet. J. Geophy Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Belian, R. D. (1997, February). Characteristic plasma properties during dispersionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitum whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderated provide and the dynamic single problem. Context of the dynamic single problem. The dynamic set of the dyn	 ., & Zhou, XZ. (2017, August). Ion velocity distributions in n events: Distributions in the central plasma sheet. J. Geophys. D14-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, doi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 at, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 agton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 Dnnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). port by kinetic-scale electromagnetic waves in fast plasma sheet <i>iophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 Dnnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021600 	543	events. J. Geophys. Res., 120, 7698-7717. doi: 10.1002/2015JA021372
 dipolarization events: Distributions in the central plasma sheet. J. Geophys. Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 n events: Distributions in the central plasma sheet. J. Geophys. 014-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, doi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021600 	544	Birn, J., Runov, A., & Zhou, XZ. (2017, August). Ion velocity distributions in
 Res., 122, 8014-8025. doi: 10.1002/2017JA024230 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispersionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitum whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderated server and the server and the server observed in association with moderated server and the server and the server observed in association with moderated server observed in associa	 014-8025. doi: 10.1002/2017JA024230 , M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, doi: 10.1029/96JA02870 , M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 at, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021600 	545	dipolarization events: Distributions in the central plasma sheet. J. Geophys.
 Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be- lian, R. D. (1997, February). Characteristic plasma properties during dispo- sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 16 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-(1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, toi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 nnnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 nnnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 514021600 	546	Res., 122, 8014-8025. doi: 10.1002/2017JA024230
 lian, R. D. (1997, February). Characteristic plasma properties during dispersionless substorm injections at geosynchronous orbit. J. Geophys. Res., 10 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitue whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderated sectors. 	 (1997, February). Characteristic plasma properties during dispertorm injections at geosynchronous orbit. J. Geophys. Res., 102, doi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space doi: 10.3389/fspas.2023.1239160 nmell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 nmell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 51A021600 	547	Birn, J., Thomsen, M. F., Borovsky, J. E., Reeves, G. D., McComas, D. J., & Be-
 sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 16 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magnetohydrodynamic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitut whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 torm injections at geosynchronous orbit. J. Geophys. Res., 102, loi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 at, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 10.4001600 	548	lian, R. D. (1997, February). Characteristic plasma properties during disper-
 2309-2324. doi: 10.1029/96JA02870 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 loi: 10.1029/96JA02870 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, 120, 8603-8615. doi: 11.04021600 	549	sionless substorm injections at geosynchronous orbit. J. Geophys. Res., 102,
 Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 M. F., & Hesse, M. (2004, May). Electron acceleration in magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. doi: 04641 at, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 10.1020/2000 	550	2309-2324. doi: 10.1029/96JA02870
 the dynamic magnetotail: Test particle orbits in three-dimensional magne- tohydrodynamic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. doi: 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitue whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 magnetotail: Test particle orbits in three-dimensional magnemic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 06L065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, C. 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 540021600 	551	Birn, J., Thomsen, M. F., & Hesse, M. (2004, May). Electron acceleration in
 tohydrodynamic simulation fields. <i>Physics of Plasmas</i>, 11, 1825-1833. do 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitum whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderate 	 mic simulation fields. Physics of Plasmas, 11, 1825-1833. doi: 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 meman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 540021600 	552	the dynamic magnetotail: Test particle orbits in three-dimensional magne-
 10.1063/1.1704641 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 04641 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i> doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, 120, 8603-8615. doi: 	553	tohydrodynamic simulation fields. <i>Physics of Plasmas</i> , 11, 1825-1833. doi:
 Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 nt, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge, ell, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i> doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>sophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 	554	10.1063/1.1704641
 T., Russell, C. T. (2008, January). Discovery of very large amplitu whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 cli, C. T. (2008, January). Discovery of very large amplitude le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & . (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 510.021600 	555	Cattell, C., Wygant, J. R., Goetz, K., Kersten, K., Kellogg, P. J., von Rosenvinge,
 whistler-mode waves in Earth's radiation belts. <i>Geophys. Res. Lett.</i>, 35, 110 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 le waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105. /2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 510.21600 	556	T., Russell, C. T. (2008, January). Discovery of very large amplitude
 doi: 10.1029/2007GL032009 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 (2007GL032009 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, <i>117</i>, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, <i>120</i>, 8603-8615. doi: 510.21600 	557	whistler-mode waves in Earth's radiation belts. Geophys. Res. Lett., 35, 1105.
 Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & Kurth, W. S. (2015, September). Van Allen Probes observations of unus ally low frequency whistler mode waves observed in association with moderat 	 eneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., & (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate rms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, <i>117</i>, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, <i>120</i>, 8603-8615. doi: 510.21600 	558	doi: 10.1029/2007GL032009
560 Kurth, W. S. (2015, September). Van Allen Probes observations of unus 561 ally low frequency whistler mode waves observed in association with moderat	 (2015, September). Van Allen Probes observations of unusuuency whistler mode waves observed in association with moderate arms: Statistical study. <i>Geophys. Res. Lett.</i>, 42, 7273-7281. doi: 5GL065565 agton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Alam, M. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 by onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, 120, 8603-8615. doi: 510.21690 	559	Cattell, C. A., Breneman, A. W., Thaller, S. A., Wygant, J. R., Kletzing, C. A., &
ally low frequency whistler mode waves observed in association with moderat	 uency whistler mode waves observed in association with moderate rms: Statistical study. Geophys. Res. Lett., 42, 7273-7281. doi: 5GL065565 agton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet eophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 510.21600 	560	Kurth, W. S. (2015, September). Van Allen Probes observations of unusu-
by the induction of the second	 Geophys. Res. Lett., 42, 7273-7281. doi: GGL065565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet eophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 	561	any low frequency whistler mode waves observed in association with moderate
⁵⁶² magnetic storms: Statistical study. <i>Geophys. Res. Lett.</i> , 42, 1213-1281. di	 bGL005565 ngton, S. R., Longley, W. J., Aldhurais, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 	562	magnetic storms: Statistical study. Geophys. Res. Lett., 42, 1213-1281. doi:
10.1002/2010GL0000000	 Igton, S. R., Longley, W. J., Aldnurals, S. A., Alam, S. S., Al- Li, W. (2023). Simulation of radiation belt wave-particle in an mhd-particle framework. <i>Frontiers in Astronomy and Space</i>. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. <i>J. Geophys. Res.</i>, 120, 8603-8615. doi: 510.21690 	563	10.1002/2019GL009909
⁵⁶⁴ Chan, A. A., Elkington, S. R., Longley, W. J., Aldnurals, S. A., Alam, S. S., Al-	 I. I., W. (2023). Simulation of radiation bert wave-particle in an mhd-particle framework. Frontiers in Astronomy and Space. doi: 10.3389/fspas.2023.1239160 onnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 510.21690 	564	Chan, A. A., Elkington, S. R., Longley, W. J., Aldnurals, S. A., Alam, S. S., Al-
565 Dert, J. M., Ll, W. (2023). Simulation of radiation belt wave-particle	 an innd-particle framework. Frontiers in Astronomy and Space . doi: 10.3389/fspas.2023.1239160 connell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 connell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 	565	bert, J. M., Li, W. (2023). Simulation of radiation belt wave-particle
566 Interactions in an inno-particle framework. Frontiers in Astronomy and Spa	 a. doi: 10.3539/18pa3.2023.1259100 connell, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 connell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 51A021600 	566	Sciences 10 doi: 10.2280/famor 2022.1220160
567 Sciences, 10. doi: 10.3369/15pas.2023.1239100	 binnen, J. W., Clausen, L., & Angelopoulos, V. (2012, September). sport by kinetic-scale electromagnetic waves in fast plasma sheet <i>cophys. Res.</i>, 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 51A021600 	567	Chasten C. C. Dennell, J. W. Clausen J. & Angeleneules, V. (2012, Sentember)
568 Chastoli, C. C., Donnell, J. W., Clausen, L., & Angelopoulos, V. (2012, September	 port by kinetic-scale electromagnetic waves in fast plasma sheet cophys. Res., 117, 9202. doi: 10.1029/2012JA017863 onnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 54021690 	568	Energy transport by kinetic cash electromegnetic waves in fast plasma sheet
for a flow <i>L Ceophys Res</i> 117 0202 doi: 10.1020/20121A017862	 Dyngs. Res., 117, 5202. doi: 10.1029/20125A011605 Donnell, J. W., Kletzing, C. A., Hospodarsky, G. B., Wygant, J. R., W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 51A021600 	509	forms I Combus Res 117 0202 doi: 10.1020/20121A017863
Chaston C C Bonnoll I W Klatzing C A Hagadavalue C D Weigent I D	W. (2015, October). Broadband low-frequency electromagnetic inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: MA021600	570	Chaston C C Bonnell I W Klatzing C A Hospodevalue C D Wegent I D
571 Unaston, U. U., Donnen, J. W., Kletzing, U. A., nospodarsky, G. D., Wygant, J. K	inner magnetosphere. J. Geophys. Res., 120, 8603-8615. doi: 510.021600	571	la Smith C W (2015 October) Broadband low frequency electrometric
ways in the inner magnetosphero I Coophie Res 100 8602 8615 d	$\frac{1}{1000} \frac{1}{1000} \frac{1}{1000$	572	wayes in the inner magnetosphere I Coophus Res 100 2603 2615 doi:
$10\ 1002\/2015\]\Delta\ 021600$		5/3	10 1002/2015IA021690
	Cassak P. Jia X. Gombosi T. I. Slavin I. A. Henderson	57F	Chen Y Tóth G. Cassak P. Jia X. Combosi T. I. Slavin I. A. Hondorson
575 Chen, Y., Tóth, G., Cassak P. Jia X. Gombosi T. I. Slavin, J. A. Henderso	·· · · · · · · · · · · · · · · · · · ·	576	M. G. (2017, October). Global Three-Dimensional Simulation of Earth's Dav-
^{5/4} Chen, Y., Tóth, G., Cassak, P., Jia, X., Gombosi, T. I., Slavin, J. A., Henderso		576	M. G. (2017, October). Global Three-Dimensional Simulation of Earth's Day-

577	side Reconnection Using a Two-Way Coupled Magnetohydrodynamics With
578	Embedded Particle-in-Cell Model: Initial Results. Journal of Geophysical Re-
579	search (Space Physics), 122(10), 10,318-10,335. doi: 10.1002/2017JA024186
580	Cheng, L., Lin, Y., Perez, J. D., Johnson, J. R., & Wang, X. (2020, February).
581	Kinetic Alfvén Waves From Magnetotail to the Ionosphere in Global Hybrid
582	Simulation Associated With Fast Flows. Journal of Geophysical Research
583	(Space Physics), 125(2), e27062. doi: 10.1029/2019JA027062
584	Chirikov, B. V. (1979, May). A universal instability of many-dimensional oscillator
585	systems. Physics Reports, 52, 263-379. doi: 10.1016/0370-1573(79)90023-1
586	Cully, C. M., Bonnell, J. W., & Ergun, R. E. (2008, June). THEMIS observations
587	of long-lived regions of large-amplitude whistler waves in the inner magneto-
588	sphere. Geophys. Res. Lett., 35, 17. doi: 10.1029/2008GL033643
589	Denton, R. E., Takahashi, K., Galkin, I. A., Nsumei, P. A., Huang, X., Reinisch,
590	B. W., Hughes, W. J. (2006, April). Distribution of density along magneto-
591	spheric field lines. J. Geophys. Res., 111, 4213. doi: 10.1029/2005JA011414
592	Desai, R. T., Eastwood, J. P., Horne, R. B., Allison, H. J., Allanson, O., Watt,
593	C. E. J., Chittenden, J. P. (2021, October). Drift Orbit Bifurcations and
594	Cross-Field Transport in the Outer Radiation Belt: Global MHD and Inte-
595	grated Test-Particle Simulations. Journal of Geophysical Research (Space
596	<i>Physics</i>), 126(10), e29802. doi: 10.1029/2021JA029802
597	Elkington, S. R., Chan, A. A., Javnes, A. N., Malaspina, D., & Albert, J. (2019)
598	December). K2: Towards a Comprehensive Simulation Framework of the Van
599	Allen Radiation Belts. In Agu fall meeting abstracts (Vol. 2019, p. SM44B-01).
600	Elkington, S. R., Chan, A. A., Li, Z., Hudson, M. K., Jaynes, A. N., & Baker, D. N.
601	(2018, December). Generalizing Global Simulations of the Radiation Belts:
602	Addressing Advective and Diffusive Processes in a Common Simulation Frame-
603	work. In Agu fall meeting abstracts (Vol. 2018, p. SM11B-02).
604	Ergun, R. E., Goodrich, K. A., Stawarz, J. E., Andersson, L., & Angelopoulos, V.
605	(2015, March). Large-amplitude electric fields associated with bursty bulk flow
606	braking in the Earth's plasma sheet. J. Geophys. Res., 120, 1832-1844. doi:
607	10.1002/2014JA020165
608	Eshetu, W. W., Lyon, J. G., Hudson, M. K., & Wiltberger, M. J. (2018, November).
609	Pitch Angle Scattering of Energetic Electrons by BBFs. Journal of Geophysical
610	Research (Space Physics), 123(11), 9265-9274. doi: 10.1029/2018JA025788
611	Eshetu, W. W., Lyon, J. G., Hudson, M. K., & Wiltberger, M. J. (2019, Febru-
612	ary). Simulations of Electron Energization and Injection by BBFs Using
613	High-Resolution LFM MHD Fields. Journal of Geophysical Research (Space
614	<i>Physics</i>), 124(2), 1222-1238. doi: 10.1029/2018JA025789
615	Frantsuzov, V. A., Artemyev, A. V., Zhang, XJ., Allanson, O., Shustov, P. I., &
616	Petrukovich, A. A. (2023, February). Diffusive scattering of energetic elec-
617	trons by intense whistler-mode waves in an inhomogeneous plasma. Journal of
618	<i>Plasma Physics</i> , $89(1)$, 905890101. doi: 10.1017/S0022377822001271
619	Gabrielse, C., Angelopoulos, V., Runov, A., & Turner, D. L. (2012, October). The
620	effects of transient, localized electric fields on equatorial electron acceleration
621	and transport toward the inner magnetosphere. J. Geophys. Res., 117, 10213.
622	doi: 10.1029/2012JA017873
623	Gan, L., Li, W., Ma, Q., Artemyev, A. V., & Albert, J. M. (2022, May). Depen-
624	dence of Nonlinear Effects on Whistler-Mode Wave Bandwidth and Amplitude:
625	A Perspective From Diffusion Coefficients. Journal of Geophysical Research
626	(Space Physics), 127(5), e30063. doi: 10.1029/2021JA030063
627	Glauert, S. A., & Horne, R. B. (2005, April). Calculation of pitch angle and energy
628	diffusion coefficients with the PADIE code. J. Geophys. Res., 110, 4206. doi:
629	10.1029/2004JA010851
630	Hsieh, YK., Kubota, Y., & Omura, Y. (2020, February). Nonlinear Evolution
631	of Radiation Belt Electron Fluxes Interacting With Oblique Whistler Mode

632	Chorus Emissions. Journal of Geophysical Research (Space Physics), 125(2),
633	e27465. doi: $10.1029/2019JA027465$
634	Hsieh, YK., & Omura, Y. (2017). Study of wave-particle interactions for whistler
635	mode waves at oblique angles by utilizing the gyroaveraging method. Radio
636	Science, 52(10), 1268–1281. Retrieved from http://dx.doi.org/10.1002/
637	2017RS006245 (2017RS006245) doi: 10.1002/2017RS006245
638	Hsieh, YK., & Omura, Y. (2023, June). Precipitation Rates of Electrons Inter-
639	acting With Lower-Band Chorus Emissions in the Inner Magnetosphere. Jour-
640	nal of Geophysical Research (Space Physics), 128(6), e2023JA031307. doi: 10
641	.1029/2023JA031307
642	Hsieh, YK., Omura, Y., & Kubota, Y. (2022, January). Energetic Elec-
643	tron Precipitation Induced by Oblique Whistler Mode Chorus Emissions
644	Journal of Geonbusical Research (Snace Physics) 127(1) e29583 doi:
645	10 1029/2021.JA029583
645	Hull A I Chaston C C Bonnell I W Damiano P A Wygant I B k
040	Reaves C. D. (2020 Sentember) Correlations Between Dispersive Alfvén
647	Wave Activity Electron Energization, and Ion Outflow in the Inner Magnete
648	wave Activity, Electron Energization, and for Outflow in the finite Magneto- sphere Coophys. P_{00} Lett. $/7/(17)$ approx doi: 10.1020/20200CL022025
649	sphere. Geophys. Res. Lett., $47(17)$, 600905. doi: 10.1029/2020GL000905
650	Inall, U. S., & Dell, I. F. (1977, July). The plasmapause as a vLr wave guide. J .
651	Geophys. Res., 82, 2819-2827. doi: 10.1029/JA0821019p02819
652	Itin, A. P., Neishtadt, A. I., & Vasiliev, A. A. (2000, July). Captures into resonance
653	and scattering on resonance in dynamics of a charged relativistic particle in
654	magnetic field and electrostatic wave. Physica D: Nonlinear Phenomena, 141,
655	281-296. doi: 10.1016/S0167-2789(00)00039-7
656	Karpman, V. I. (1974, September). Nonlinear Effects in the ELF Waves Propagating
657	along the Magnetic Field in the Magnetosphere. Space Sci. Rev., 16, 361-388.
658	doi: 10.1007/BF00171564
659	Karpman, V. I., Istomin, I. N., & Shkliar, D. R. (1975, May). Effects of nonlinear
660	interaction of monochromatic waves with resonant particles in the inhomoge-
661	neous plasma. <i>Physica Scripta</i> , 11, 278-284. doi: 10.1088/0031-8949/11/5/
662	008
663	Kennel, C. F., & Engelmann, F. (1966, November). Velocity Space Diffusion from
664	Weak Plasma Turbulence in a Magnetic Field. <i>Physics of Fluids</i> , 9, 2377-2388.
665	doi: 10.1063/1.1761629
666	Khazanov, G. V., Tel'nikhin, A. A., & Kronberg, T. K. (2014, Jan). Stochastic elec-
667	tron motion driven by space plasma waves. Nonlinear Processes in Geophysics,
668	21(1), 61-85. doi: $10.5194/npg-21-61-2014$
669	Kubota, Y., & Omura, Y. (2018, June). Nonlinear Dynamics of Radiation
670	Belt Electrons Interacting With Chorus Emissions Localized in Longitude.
671	Journal of Geophysical Research (Space Physics), 123, 4835-4857. doi:
672	10.1029/2017JA025050
673	Lemons, D. S. (2012, January). Pitch angle scattering of relativistic electrons from
674	stationary magnetic waves: Continuous Markov process and quasilinear theory.
675	Physics of Plasmas, 19(1), 012306. doi: 10.1063/1.3676156
676	Li, W., & Hudson, M. K. (2019, Nov). Earth's Van Allen Radiation Belts: From
677	Discovery to the Van Allen Probes Era. Journal of Geophysical Research
678	(Space Physics), 124(11), 8319-8351, doi: 10.1029/2018JA025940
679	Liang, H., Ashour-Abdalla, M., Richard, R. Schriver, D. El-Alaoui, M. & Walker
680	B. J. (2014, July). Contrasting electron acceleration processes during two sub-
681	storms. Journal of Geophysical Research (Space Physics) 119(7) 5382-5400
682	doi: 10.1002/2013JA019721
602	Lichtenberg A I & Lieberman M A (1983) Regular and stochastic motion
003	Lin V Wang X V Lu S Parez I D & Lu O (2014 September) Investi
084	ration of storm time magnetotail and ion injection using three dimensional
085	Samon or storm time magnetotian and for injection using timee-dimensional

global hybrid simulation. J. Geophys. Res., 119, 7413-7432. doi: 10.1002/

 Lin, Y., Wing, S., Johnson, J. R., Wang, X. Y., Perez, J. D., & Cheng, L. (2017, June). Formation and transport of entropy structures in the magnetotail simulated with a 3-D global hybrid code. Geophys. Res. Lett., 44, 5892-5899. doi: 10.1002/2017GL073957 Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August). The ion temperature gradient: An intrinsic property of Earth's magnetotail. J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA022009 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchert, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygaut, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Morkin, V. G. (2023). Cross-Scale Modelling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essocar.108941486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 126, 267-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème,	687	2014JA020005
 June). Formation and transport of entropy structures in the magnetotall simulated with a 3-D global hybrid code. Geophys. Res. Lett., 44, 5892-5899. doi: 10.1002/2017GL073957 Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August). The ion temperature gradient: An intrinsic property of Earth's magnetotail. J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023252 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Seale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., V., Walsov, A. (2012, Outly). June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4970-4999. doi: 10.1029/2018JA0254117 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they a	688	Lin, Y., Wing, S., Johnson, J. R., Wang, X. Y., Perez, J. D., & Cheng, L. (2017,
 lated with a 3-D global hybrid code. Geophys. Res. Lett., 44, 5892-5899. doi: 10.1002/2017GL073957 Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August). The ion temperature gradient: An intrinsic property of Earth's magnetotail. J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Fort in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA023005 Michael, A. T., Sorathia, K. A, Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22641/essoar.169841486.67752071/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 128, 479-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures. What and where are was what they do, and how they are made. Geophys. Res. Lett., 24, 3627-3638. doi: 10.	689	June). Formation and transport of entropy structures in the magnetotail simu-
 10.1002/2017GL073957 Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August). The ion temperature gradient: An intrinsic property of Earth's magnetotail. J. Geophys. Res., 129, 8295-8309. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R. & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4970-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker,	690	lated with a 3-D global hybrid code. Geophys. Res. Lett., 44, 5892-5899. doi:
 Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August). The ion temperature gradient: An intrinsic property of Earth's magnetotail. <i>J. Geophys. Res.</i>, <i>122</i>, 8295-830. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. <i>J. Geophys. Res.</i>, <i>121</i>, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. <i>Physics of Plasmas</i>, <i>28</i>(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). <i>Quantitative aspects of magnetospheric physics</i>. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. <i>J. Geophys. Res.</i>, <i>123</i>, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. <i>ESS Open Archive</i>. doi: 10.22541/cssoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. <i>J. Geophys. Res.</i>, <i>123</i>, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. <i>Geophys. Res. Lett.</i>, <i>42</i>, 3627-3638. doi: 10.1002/2015GL063946 Nakammar, R., Baumjoham, W., Klecker, B., Bog	691	10.1002/2017 GL073957
 The ion temperature gradient: An intrinsic property of Earth's magnetotail. J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasillev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a	692	Lu, S., Artemyev, A. V., Angelopoulos, V., Lin, Y., & Wang, X. Y. (2017, August).
 J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA024209 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/vl Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J.,, Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1022/2015GL63946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 2000001. doi: 10.1029/2	693	The ion temperature gradient: An intrinsic property of Earth's magnetotail.
 Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., & Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., Ma, Q. (2012	694	J. Geophys. Res., 122, 8295-8309. doi: 10.1002/2017JA024209
 Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.2541/essocar.16984148.667752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magne	695	Lu, S., Lin, Y., Angelopoulos, V., Artemyev, A. V., Pritchett, P. L., Lu, Q., &
 asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res., 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 124, 4979-4990. doi: 10.1022/20152417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae,	696	Wang, X. Y. (2016, December). Hall effect control of magnetotail dawn-dusk
 121, 11. doi: 10.1002/2016JA023325 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. <i>Physics of Plasmas</i>, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). <i>Quantitative aspects of magnetospheric physics</i>. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. <i>J. Geophys. Res.</i>, 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. <i>ESS Open Archive</i>. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. <i>J. Geophys. Res.</i>, 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. <i>Geophys. Res. Lett.</i>, 42, 3627-3638. doi: 10.1002/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. <i>Annales Geophys. Res.</i>, 10, 5194/angec-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. <i>J. Geophys. Res.</i>, 116, 4219. doi: 10.029/2010JA016233 <	697	asymmetry: A three-dimensional global hybrid simulation. J. Geophys. Res.,
 Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. <i>Physics of Plasmas</i>, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). <i>Quantitative aspects of magnetospheric physics</i>. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. <i>J. Geophys. Res.</i>, <i>123</i>, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. <i>ESS Open Archive</i>. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. <i>J. Geophys. Res.</i>, <i>123</i>, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. <i>Geophys. Res. Lett.</i>, <i>42</i>, 3627-3638. doi: 10.1002/20105fL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. <i>Geophys. Res. Lett.</i>, <i>29</i>(20), 200000-1. doi: 10.1029/20102GL05763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. <i>Annales Geophysicae</i>, <i>30</i>, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N.	698	121, 11. doi: 10.1002/2016JA023325
 application of stochastic differential equations for simulation of nonlinear wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Cen- sus of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.10129/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electron	699	Lukin, A. S., Artemyev, A. V., & Petrukovich, A. A. (2021, September). On
 wave-particle resonant interactions. Physics of Plasmas, 28(9), 092904. doi: 10.1063/5.0058054 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Rumov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus	700	application of stochastic differential equations for simulation of nonlinear
 10:1003/5.005804 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni,	701	wave-particle resonant interactions. <i>Physics of Plasmas</i> , 28(9), 092904. doi:
 Lyons, L. R., & Williams, D. J. (1984). Quantitative aspects of magnetospheric physics. (Lyons, L. R. & Williams, D. J., Ed.). Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1022/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL63946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angco-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1002/2101JA016233 Ni, B., Thorne, R. M., Zhang, X.,	702	10.1003/5.0058054
 ⁷⁰⁴ physics. (LyORS, L. R. & WHIMARS, D. J., Ed.). ⁷⁰⁵ Malaspina, D. M., Ukhorskiy, A., Chu, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front ⁷⁰⁷ in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: ⁷⁰⁸ 10.1002/2017JA025005 ⁷⁰⁹ Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & ⁷⁰⁴ Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt ⁷⁰⁵ Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 ⁷⁰⁶ Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., ⁷⁰⁷ Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- ⁷⁰⁸ teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. ⁷⁰⁹ Res., 123, 4979-4999. doi: 10.1029/2018JA025417 ⁷⁰⁹ Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, ⁷¹⁷ S., & Vasko, I. (2015). Time domain structures: What and where they are, ⁷¹⁸ what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. ⁷¹⁹ doi: 10.1002/2015GL063946 ⁷¹⁰ Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., ⁷¹¹ Runov, A. (2002, October). Motion of the dipolarization front during a ⁷¹² flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. ⁷¹³ doi: 10.1029/2002GL015763 ⁷¹⁴ Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- ⁷¹⁵ Planck diffusion equation in non-dipolar magnetic fields with applications ⁷¹⁶ to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: ⁷¹⁷ 10.5194/angeo-30-733-2012 ⁷¹⁸ Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). ⁷¹⁹ Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- ⁷¹⁹ itation: 2. Evaluation for whistler mode chorus waves. J. Geop	703	Lyons, L. R., & Williams, D. J. (1984). <i>Quantitative aspects of magnetospheric</i>
 Malaspina, D. M., Oknorskiy, A., Chi, X., & Wygant, J. (2018, April). A Census of Plasma Waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1002/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259	704	<i>physics.</i> (Lyons, L. R. & Williams, D. J., Ed.).
 ⁷⁰⁶ sus of Flasma waves and Structures Associated With an Injection Front in the Inner Magnetosphere. J. Geophys. Res., 123, 2566-2587. doi: 10.1002/2017JA025005 ⁷⁰⁷ Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 ⁷¹⁰ Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 ⁷¹⁶ Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 ⁷¹⁰ Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 ⁷¹⁸ Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 ⁷¹⁸ Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 ⁷¹⁹ Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-	705	Malaspina, D. M., UKNOTSKIY, A., Chu, A., & Wygant, J. (2018, April). A Cen-
 ⁷⁰⁷ In the Infler Magnetosphere. J. Geophys. Res., 129, 2306-2351. doi: 10.1002/2017JA025005 ⁷⁰⁸ Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 ⁷¹⁰ Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Interaction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 ⁷¹¹ Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 ⁷¹² Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 ⁷¹⁴ Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/aageo-30-733-2012 ⁷¹⁸ Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 ⁷¹⁹ Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷¹⁴ Nunn, D. (1971, October). Wave-particle inte	706	sus of Plasma waves and Structures Associated with an injection Front
 Michael, A. T., Sorathia, K. A., Ukhorskiy, A. Y., Albert, J., Shen, X., Li, W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S00223778000006061 Omura, Y	707	In the inner Magnetosphere. $J.$ Geophys. Res., 125, 2500-2587. doi: 10.1002/2017IA025005
 Merkar, A. 1., Ordania, R. A., Ornosky, A. 1., Albert, J., Sheri, A., D., W., & Merkin, V. G. (2023). Cross-Scale Modeling of Storm-Time Radiation Belt Variability. ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffus auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miya	708	Michael A. T. Sorathia K. A. Ilkhorskiy, A. V. Albert, I. Shen, X. Li, W. K.
 Variability, ESS Open Archive. doi: 10.22541/essoar.169841486.67752077/v1 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 <li< td=""><td>709</td><td>Merkin V G (2023) Cross-Scale Modeling of Storm-Time Radiation Belt</td></li<>	709	Merkin V G (2023) Cross-Scale Modeling of Storm-Time Radiation Belt
 Mourenas, D., Zhang, XJ., Artemyev, A. V., Angelopoulos, V., Thorne, R. M., Bortnik, J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant In- teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	710	Variability ESS Open Archive doi: 10.22541/essoar 169841486.67752077/v1
 Bortnik, J., J., Vasiliev, A. A. (2018, June). Electron Nonlinear Resonant Intraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	712	Mourenas D. Zhang X - J. Artemyey A. V. Angelopoulos V. Thorne B. M.
 teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys. Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	712	Bortnik, J., Wasiliev, A. A. (2018, June). Electron Nonlinear Resonant In-
 Res., 123, 4979-4999. doi: 10.1029/2018JA025417 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Numn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	714	teraction With Short and Intense Parallel Chorus Wave Packets. J. Geophys.
 Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne, S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. <i>Geophys. Res. Lett.</i>, 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. <i>Geophys. Res. Lett.</i>, 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. <i>Annales Geophysicae</i>, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. <i>J. Geophys. Res.</i>, 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. <i>Space Sci. Rev.</i>, 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. <i>Journal of Plasma Physics</i>, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	715	Res., 123, 4979-4999. doi: 10.1029/2018JA025417
 S., & Vasko, I. (2015). Time domain structures: What and where they are, what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	716	Mozer, F. S., Agapitov, O., Artemyev, A., Drake, J. F., Krasnoselskikh, V., Lejosne,
 what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638. doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	717	S., & Vasko, I. (2015). Time domain structures: What and where they are,
 doi: 10.1002/2015GL063946 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. <i>Geophys. Res. Lett.</i>, 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. <i>Annales Geophysicae</i>, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. <i>J. Geophys. Res.</i>, 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. <i>Space Sci. Rev.</i>, 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. <i>Journal of Plasma Physics</i>, 6, 291. doi: 10.1017/S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	718	what they do, and how they are made. Geophys. Res. Lett., 42, 3627-3638.
 Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H., Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	719	doi: 10.1002/2015GL063946
 ⁷²¹ Runov, A. (2002, October). Motion of the dipolarization front during a flow burst event observed by Cluster. <i>Geophys. Res. Lett.</i>, 29(20), 200000-1. doi: 10.1029/2002GL015763 ⁷²⁴ Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. <i>Annales Geophysicae</i>, 30, 733-750. doi: 10.5194/angeo-30-733-2012 ⁷²⁶ Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. <i>J. Geophys. Res.</i>, 116, 4219. doi: 10.1029/2010JA016233 ⁷³⁷ Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. <i>Space Sci. Rev.</i>, 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷³⁸ Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. <i>Journal of Plasma Physics</i>, 6, 291. doi: 10.1017/ S0022377800006061 ⁷³⁸ Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	720	Nakamura, R., Baumjohann, W., Klecker, B., Bogdanova, Y., Balogh, A., Rème, H.,
 flow burst event observed by Cluster. Geophys. Res. Lett., 29(20), 200000-1. doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	721	Runov, A. (2002, October). Motion of the dipolarization front during a
 doi: 10.1029/2002GL015763 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	722	flow burst event observed by Cluster. Geophys. Res. Lett., $29(20)$, 200000-1.
 Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker- Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precipitation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	723	doi: 10.1029/2002GL015763
 Planck diffusion equation in non-dipolar magnetic fields with applications to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	724	Ni, B., Thorne, R. M., & Ma, Q. (2012, April). Bounce-averaged Fokker-
 to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi: 10.5194/angeo-30-733-2012 Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	725	Planck diffusion equation in non-dipolar magnetic fields with applications
 ⁷²⁷ 10.5194/angeo-30-733-2012 ⁷²⁸ Ni, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). ⁷²⁹ Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, ⁷²¹ 4219. doi: 10.1029/2010JA016233 ⁷³² Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, ⁷³³ April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., ⁷³⁴ 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷³⁵ Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an ⁷³⁶ inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ ⁷³⁷ S0022377800006061 ⁷³⁸ Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	726	to the Dungey magnetosphere. Annales Geophysicae, 30, 733-750. doi:
 ⁷²⁸ NI, B., Thorne, R. M., Meredith, N. P., Horne, R. B., & Shprits, Y. Y. (2011, April). ⁷²⁹ Resonant scattering of plasma sheet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 ⁷³² Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷³⁵ Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 ⁷³⁶ Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	727	10.5194/angeo-30-(33-2012
 ⁷²⁹ Resonant scattering of plasma sneet electrons leading to diffuse auroral precip- ⁷³⁰ itation: 2. Evaluation for whistler mode chorus waves. J. Geophys. Res., 116, ⁷³¹ 4219. doi: 10.1029/2010JA016233 ⁷³² Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, ⁷³³ April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., ⁷³⁴ 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷³⁵ Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an ⁷³⁶ inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ ⁷³⁷ S0022377800006061 ⁷³⁸ Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	728	NI, B., LHORDE, K. M., MERCHARD, N. P., HORDE, K. B., & Shprits, Y. Y. (2011, April).
 ration. 2. Evaluation for winster mode chorus waves. J. Geophys. Res., 116, 4219. doi: 10.1029/2010JA016233 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	729	resonant scattering of plasma sneet electrons leading to diffuse auroral precip- itation: 2. Evaluation for whistler mode chorus waves 1. Combus. Pro-
 Ni, B., Thorne, R. M., Zhang, X., Bortnik, J., Pu, Z., Xie, L., Gu, X. (2016, April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	730	1000000000000000000000000000000000000
 April). Origins of the Earth's Diffuse Auroral Precipitation. Space Sci. Rev., 200, 205-259. doi: 10.1007/s11214-016-0234-7 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	731	Ni B Thome B M Zhang X Bortnik I Du Z Vie I $C_{\rm D}$ V (2016
 ¹¹³ 200, 205-259. doi: 10.1007/s11214-016-0234-7 ⁷³⁴ Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an ¹⁷⁶ inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ ¹⁷⁷ S0022377800006061 ⁷³⁸ Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	732	April) Origins of the Earth's Diffuse Auroral Precipitation Space Sci Rev
 Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	734	200. 205-259. doi: 10.1007/s11214-016-0234-7
 inhomogeneous medium. Journal of Plasma Physics, 6, 291. doi: 10.1017/ S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	735	Nunn, D. (1971, October). Wave-particle interactions in electrostatic waves in an
 S0022377800006061 Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y., 	736	inhomogeneous medium. Journal of Plasma Physics. 6, 291. doi: 10.1017/
Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y.,	737	S0022377800006061
, , , ,, ,,,,,	738	Omura, Y., Miyashita, Y., Yoshikawa, M., Summers, D., Hikishima, M., Ebihara, Y.,
⁷³⁹ & Kubota, Y. (2015, November). Formation process of relativistic electron flux	739	& Kubota, Y. (2015, November). Formation process of relativistic electron flux
through interaction with chorus emissions in the Earth's inner magnetosphere.	740	through interaction with chorus emissions in the Earth's inner magnetosphere.
	741	J. Geophys. Res., 120, 9545-9562. doi: 10.1002/2015JA021563
I Ceophus Res 100 0545 0569 doi: 10 1009/90151A091569	/41	5. Geophys. Res., 120, 5545-5502. doi: 10.1002/2015JA021505

- Orlova, K. G., & Shprits, Y. Y. (2010, March). Dependence of pitch-angle scattering
 rates and loss timescales on the magnetic field model. *Geophys. Res. Lett.*, 37,
 5105. doi: 10.1029/2009GL041639
- Pan, Q., Ashour-Abdalla, M., Walker, R. J., & El-Alaoui, M. (2014, February).
 Electron energization and transport in the magnetotail during substorms.
 Journal of Geophysical Research (Space Physics), 119(2), 1060-1079. doi: 10.1002/2013JA019508
- Panov, E. V., Artemyev, A. V., Baumjohann, W., Nakamura, R., & Angelopoulos,
 V. (2013, June). Transient electron precipitation during oscillatory BBF brak ing: THEMIS observations and theoretical estimates. J. Geophys. Res., 118,
 3065-3076. doi: 10.1002/jgra.50203
- Peroomian, V., & El-Alaoui, M. (2008, June). The storm-time access of solar wind
 ions to the nightside ring current and plasma sheet. J. Geophys. Res., 113,
 A06215. doi: 10.1029/2007JA012872
- Peroomian, V., & Zelenyi, L. M. (2001, January). Large-Scale Kinetic Modeling of
 Magnetotail Dynamics. Space Sci. Rev., 95, 257-271.
- Schulz, M., & Lanzerotti, L. J. (1974). Particle diffusion in the radiation belts.
 Springer, New York.
- Sheeley, B. W., Moldwin, M. B., Rassoul, H. K., & Anderson, R. R. (2001, November). An empirical plasmasphere and trough density model: CRRES observations. J. Geophys. Res., 106, 25631-25642. doi: 10.1029/2000JA000286
 - Shklyar, D. R. (2021, February). A Theory of Interaction Between Relativistic Electrons and Magnetospherically Reflected Whistlers. Journal of Geophysical Research (Space Physics), 126(2), e28799. doi: 10.1029/2020JA028799
- Shklyar, D. R., & Matsumoto, H. (2009, April). Oblique Whistler-Mode Waves in the Inhomogeneous Magnetospheric Plasma: Resonant Interactions with Energetic Charged Particles. Surveys in Geophysics, 30, 55-104. doi: 10.1007/s10712-009-9061-7
- Shprits, Y. Y., Subbotin, D. A., Meredith, N. P., & Elkington, S. R. (2008, November). Review of modeling of losses and sources of relativistic electrons in the outer radiation belt II: Local acceleration and loss. *Journal of Atmospheric and Solar-Terrestrial Physics*, 70, 1694-1713. doi: 10.1016/j.jastp.2008.06.014
 - Sinitsyn, A., Dulov, E., & Vedenyapin, V. (2011). *Kinetic Boltzmann, Vlasov and Related Equations*. Elsevier.
 - Solovev, V. V., & Shkliar, D. R. (1986). Particle heating by a low-amplitude wave in an inhomogeneous magnetoplasma. *Sov. Phys. JETP*, 63, 272-277.
- Sorathia, K. A., Ukhorskiy, A. Y., Merkin, V. G., Fennell, J. F., & Claudepierre,
 S. G. (2018, July). Modeling the Depletion and Recovery of the Outer Radiation Belt During a Geomagnetic Storm: Combined MHD and Test Particle
 Simulations. Journal of Geophysical Research (Space Physics), 123(7), 5590-5609. doi: 10.1029/2018JA025506
- 783 Stix, T. H. (1962). The Theory of Plasma Waves.

763

764

765

774

775

776

777

- Tao, X., Bortnik, J., Albert, J. M., Thorne, R. M., & Li, W. (2013, July). The importance of amplitude modulation in nonlinear interactions between electrons and large amplitude whistler waves. *Journal of Atmospheric and Solar-Terrestrial Physics*, 99, 67-72. doi: 10.1016/j.jastp.2012.05.012
- Tao, X., Chan, A. A., Albert, J. M., & Miller, J. A. (2008, July). Stochastic model ing of multidimensional diffusion in the radiation belts. *Journal of Geophysical Research (Space Physics)*, 113(A7), A07212. doi: 10.1029/2007JA012985
- Tao, X., Thorne, R. M., Li, W., Ni, B., Meredith, N. P., & Horne, R. B. (2011, April). Evolution of electron pitch angle distributions following injection from the plasma sheet. J. Geophys. Res., 116, A04229. doi: 10.1029/ 2010JA016245
- Thorne, R. M., Bortnik, J., Li, W., & Ma, Q. (2021). Wave-particle interactions
 in the earth's magnetosphere. In *Magnetospheres in the solar system* (p. 93-

797	108). American Geophysical Union (AGU). doi: https://doi.org/10.1002/
798	Tanaian D.C. Antanaway A.V. Zhang V. I. Chauday M.M. & Vainahtain D. I.
799	(2022 August) Decreases have during effect for relativistic electron interaction
800	(2022, August). Resonance broadening effect for relativistic electron interaction with electromegnetic ion evelotron waves <u>Physics of Plasmas</u> $00(8)$ 082002
801	with electromagnetic for cyclotron waves. Thysics of Thusmus, $29(6)$, 082905 .
802	Tulon E. Dreneman A. Cattell C. Warrent I. Theller S. & Melegnine D.
803	(2010 Mar) Statistical Occurrence and Distribution of High Amplitude
804	Whistler Mode Ways in the Outer Radiation Bolt
805	Whistler Mode waves in the Otter Radiation Bett. Geophys. Res. Lett., $(6(5), 2328, 2336, doi: 10.1020/2010CL082202$
806	40(5), 2526-2550. doi: 10.1029/2019GL062292
807	Malacrina D M & Schwartz S I (2022 March) Cross scale operations
808	naidspilla, D. M., & Schwartz, S. J. (2022, March). Cross-scale energy cascade
809	$10\ 1038/c/1508-022-08038-v$
011	Ilkhorskiv A V Sorathia K A Merkin V C Sitnov M I Mitchell D C
811	& Gkioulidou M (2018 Jul) Ion Tranning and Acceleration at Dipo-
012	larization Fronts: High-Resolution MHD and Test-Particle Simulations
814	Journal of Geophysical Research (Space Physics) 123(7) 5580-5589 doi:
815	10.1029/2018JA025370
816	Vainchtein, D., Zhang, X. J., Artemyey, A. V., Mourenas, D., Angelopoulos, V.,
817	& Thorne, R. M. (2018, October). Evolution of Electron Distribution
818	Driven by Nonlinear Resonances With Intense Field-Aligned Chorus Waves.
819	Journal of Geophysical Research (Space Physics), 123(10), 8149-8169. doi:
820	10.1029/2018JA025654
821	Vedenov, A. A., Velikhov, E., & Sagdeev, R. (1962). Quasilinear theory of plasma
822	oscillations. Nuclear Fusion Suppl., 2, 465-475.
823	Walker, R. J., Lapenta, G., Liang, H., Berchem, J., El-Alaoui, M., & Goldstein,
824	M. L. (2018, October). Structure and Dynamics of Three-Dimensional Mag-
825	netotail Reconnection. Journal of Geophysical Research (Space Physics),
826	123(10), 8241-8260. doi: $10.1029/2018$ JA025509
827	Wang, G., Su, Z., Zheng, H., Wang, Y., Zhang, M., & Wang, S. (2017). Nonlin-
828	ear fundamental and harmonic cyclotron resonant scattering of radiation belt
829	ultrarelativistic electrons by oblique monochromatic emic waves. J. Geo-
830	phys. Res., 122(2), 1928-1945. Retrieved from http://dx.doi.org/10.1002/
831	2016JA023451 doi: 10.1002/2016JA023451
832	Wilson, L. B., III, Cattell, C. A., Kellogg, P. J., Wygant, J. R., Goetz, K., Bren-
833	eman, A., & Kersten, K. (2011, September). The properties of large am-
834	plitude whistler mode waves in the magnetosphere: Propagation and rela-
835	tionship with geomagnetic activity. Geophys. Res. Lett., 38, 17107. doi: 10.1020/2011/CL.042671
836	Wilthomen M. Markin V. Luon I. C. & Oktoni S. (2015 June) High
837	wittberger, M., Merkin, V., Lyon, J. G., & Ontani, S. (2015, Julie). High-
838	Lewrond of Coophysical Research (Space Physica) 120(6) 4555 4566
839	$101002/2015I\Lambda021080$
840	Zaclavskij C. M. Zakharov, M. I. Noishtadt, A. I. Sagdoov, B. Z., & Heikov, D. A.
841	(1989 November) Multidimensional Hamiltonian chaos Zhurnal Eksnerimen-
8/3	talnoi i Teoreticheskoi Fiziki 96 1563-1586
844	Zhang X J Agapitov O Artemyev A V Mourenas D Angelopoulos V
845	Kurth, W. S., Hospodarsky, G. B. (2020, October) Phase Decoherence
846	Within Intense Chorus Wave Packets Constrains the Efficiency of Nonlinear
847	Resonant Electron Acceleration. Geophys. Res. Lett. $47(20)$. e89807. doi:
848	10.1029/2020GL089807
849	Zhang, XJ., Angelopoulos, V., Ni, B., & Thorne, R. M. (2015, January). Predom-
850	inance of ECH wave contribution to diffuse aurora in Earth's outer magneto-
851	sphere. J. Geophys. Res., 120, 295-309. doi: 10.1002/2014JA020455

852	Zhang, XJ., Artemyev, A., Angelopoulos, V., Tsai, E., Wilkins, C., Kasahara, S.,
853	Matsuoka, A. (2022, March). Superfast precipitation of energetic electrons
854	in the radiation belts of the Earth. Nature Communications, 13, 1611. doi:
855	10.1038/s41467-022-29291-8
856	Zhang, X. J., Demekhov, A. G., Katoh, Y., Nunn, D., Tao, X., Mourenas, D.,
857	Angelopoulos, V. (2021, August). Fine Structure of Chorus Wave
858	Packets: Comparison Between Observations and Wave Generation Mod-
859	els. Journal of Geophysical Research (Space Physics), 126(8), e29330. doi:
860	10.1029/2021JA029330
861	Zhang, X. J., Mourenas, D., Artemyev, A. V., Angelopoulos, V., Bortnik, J.,
862	Thorne, R. M., Hospodarsky, G. B. (2019, July). Nonlinear Electron
863	Interaction With Intense Chorus Waves: Statistics of Occurrence Rates. Geo-
864	phys. Res. Lett., 46(13), 7182-7190. doi: 10.1029/2019GL083833
865	Zhang, X. J., Thorne, R., Artemyev, A., Mourenas, D., Angelopoulos, V., Bortnik,
866	J., Hospodarsky, G. B. (2018, July). Properties of Intense Field-Aligned
867	Lower-Band Chorus Waves: Implications for Nonlinear Wave-Particle Inter-
868	actions. Journal of Geophysical Research (Space Physics), 123(7), 5379-5393.
869	doi: 10.1029/2018JA025390
870	Zheng, L., Chan, A. A., Albert, J. M., Elkington, S. R., Koller, J., Horne, R. B.,
871	Meredith, N. P. (2014, September). Three-dimensional stochastic modeling
872	of radiation belts in adiabatic invariant coordinates. Journal of Geophysical
873	Research (Space Physics), 119(9), 7615-7635. doi: 10.1002/2014JA020127
874	Zheng, L., Chen, L., & Zhu, H. (2019, May). Modeling Energetic Electron Nonlinear
875	Wave-Particle Interactions With Electromagnetic Ion Cyclotron Waves. Jour-
876	nal of Geophysical Research (Space Physics), 124(5), 3436-3453. doi: 10.1029/
877	2018JA 026156
878	Zhou, M., El-Alaoui, M., Lapenta, G., Berchem, J., Richard, R. L., Schriver, D., &
879	Walker, R. J. (2018, October). Suprathermal Electron Acceleration in a Recon-
880	necting Magnetotail: Large-Scale Kinetic Simulation. Journal of Geophysical
881	Research (Space Physics), 123(10), 8087-8108. doi: 10.1029/2018JA025502