Effects of Upper-Hybrid Waves near the EDR: Change of Pressure Tensor and E field

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Introduction: Crescent Electrons

- Near EDRs
- Meandering motion of electron
- Expected by Hesse [2014]
- First observed by Burch [2016]

Crescent Electrons

Beam-plasma Interaction

- Crescent and Core
- Large amplitude ES wave
- Thermalize or energize electrons
Introduction: High-Frequency Wave near EDR

Nonlinear Harmonics and EM radiation
- Nonlinear beam-plasma interaction
- EM Radiation from wave-wave interactions

Beam-mode and Bernstein-mode from agyrotropic electron
- The same generation mechanism: Interaction between agyrotropic beam and core.

[Dokgo et al., 2019, GRL]

[Li et al., 2020, Nat. Comm.]

[Dokgo et al., 2020, GRL]
Overview

- 2017 July 3rd Event (MMS3)
- UTC 05:26:50.200-51.200, 1sec data

EDR features

- Electron perp. Temp. increase
- Discrepancies between bulk electron velocities and $E \times B$
- Finite $J \cdot E'$
- Crescent-shape electron distribution

Strong E-field perturbations

- Max. amplitude : $\sim$150 mV/m
- Frequency : $\sim$ Fpe ($\sim$4kHz)
July 03 Event: PIC simulation

Time history of Energy and Pressure tensors

- The increase rate of electron kinetic energy agrees with the MMS observation measured by $J \cdot E'$
- $P_{yz}$ increases due to the core population.
- $\text{Sqrt}(Q)$ decreases
- $P_{yz}$ and $\text{Sqrt}(Q)$ can be changed oppositely.

[ Dokgo et al., in prep. ]
More runs using various beam densities

- Change of Pyz depends on the beam density.
- $N_{\text{beam}} < 0.13$: Pyz increase
- $N_{\text{beam}} > 0.13$: Pyz decreases
- Current Jy decreases as a result of beam-plasma interaction

[Dokgo et al., in prep.]
Plasma Parameters near EDR

(a) Profiles of Plasma Parameter

(b) Weak case

(c) Strong case

Schematic diagram of plasma profiles w/ and w/o UHW

- Weak beam case: Ey field can be enhanced
- Strong beam case: Reversal of Ey field can be formed

[Dokgo et al., in prep.]
Effects of UHW

UHW

Wave-particle Interaction

Change Pyz

Jy decrease

Change Ey

Change $J_y \cdot E_y$

Energy Conversion
We performed 2D PIC simulation for the generation of upper-hybrid waves near the EDR.

Electron energization (heating) rate via wave-particle interaction agrees with the MMS observation measured by $J \cdot E'$.

The gyrotropy factor $\sqrt{Q}$ and current $J_y$ decreased as a result of wave activity.

Off-diagonal pressure tensor $P_{yz}$
- increased when $N_{\text{beam}} < 0.13$
- decreased when $N_{\text{beam}} > 0.13$

These changes of parameter can affect $J_y \cdot E'$ near the EDR.

Thank you.