Numerical and *in-situ* analysis of Kelvin-Helmholtz instability

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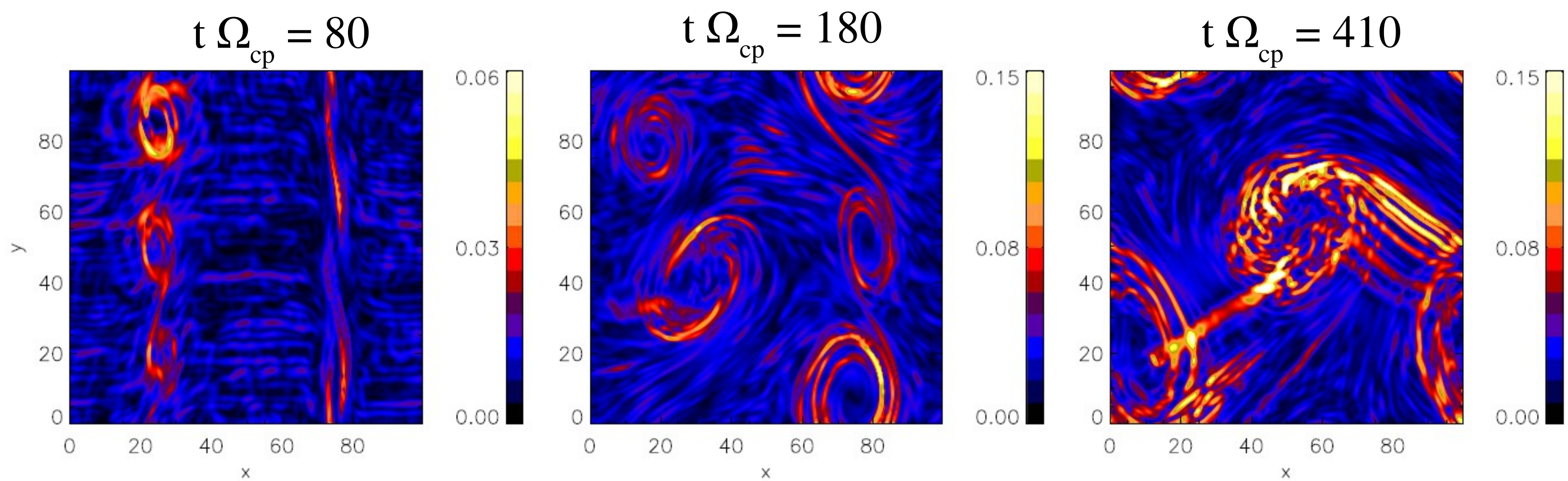
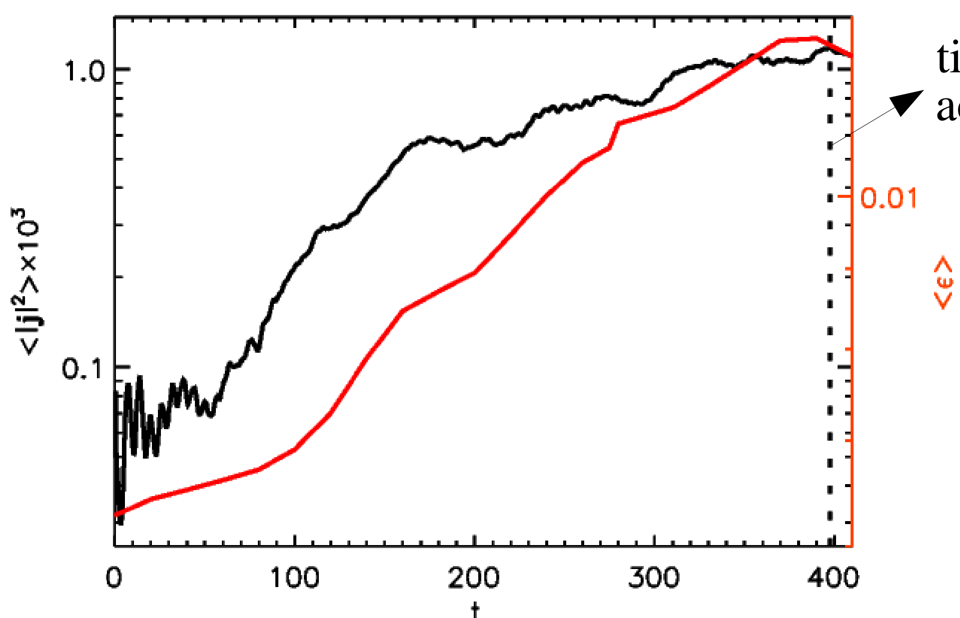
2.5D – 3V HYBRID SIMULATION

We start from an exact equilibrium configuration (*Malara et al.* PRE, 2018)

Current density





time of the maximum activity of **j**

Settino et al. ApJ, 2020a

Non – Maxwellianity parameter

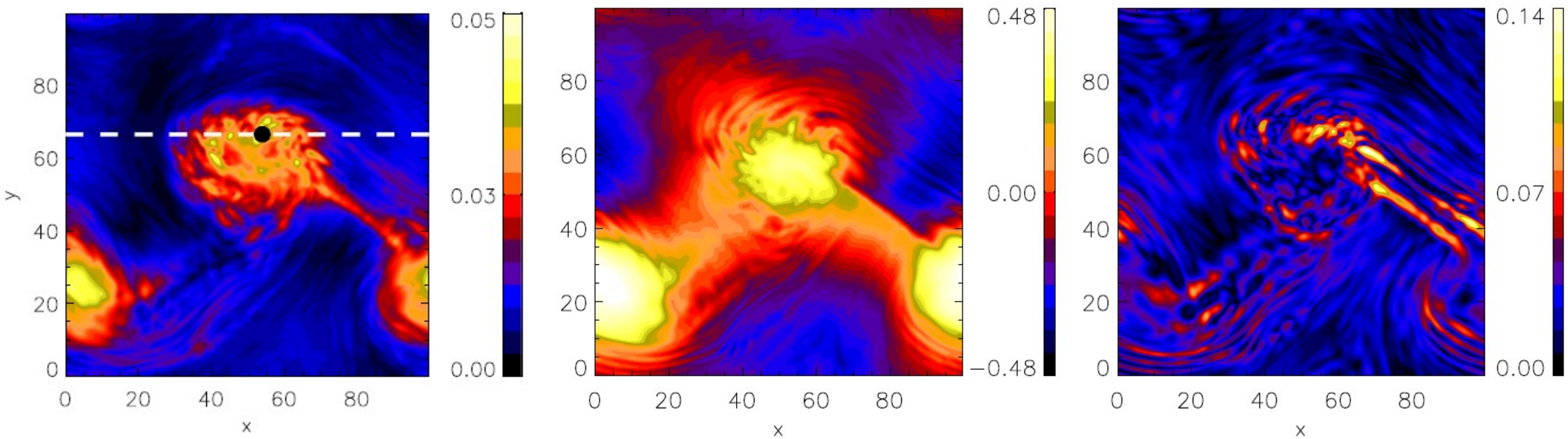
$$\varepsilon(x,y,t) = \frac{1}{n}\sqrt{\int \left[f(\mathbf{x},\mathbf{u},t) - f_M(\mathbf{x},\mathbf{u},t)\right]^2 d^3\mathbf{u}}$$

Greco et al. PRE, 2012

j and ε are highly correlated in time

Kinetic features in KHI

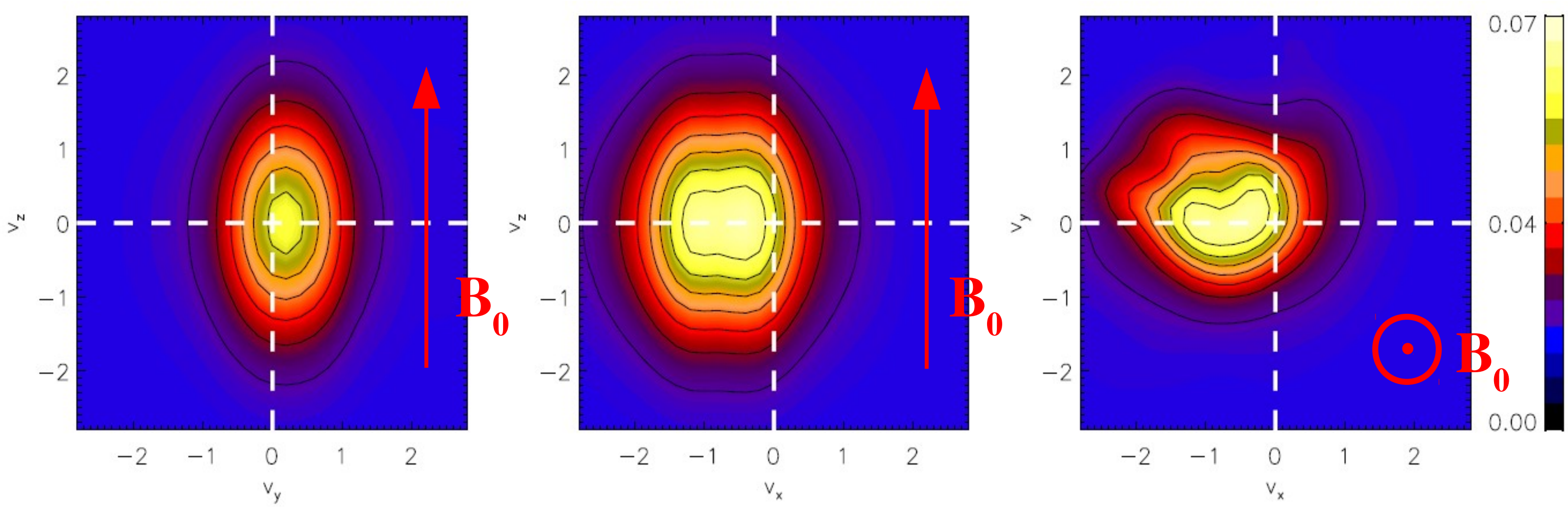
Non-Maxwellianity parameter | **Temperature anisotropy ($1 - T_{\perp}/T_{\parallel}$)** | **Agyrotropy ($\sqrt{Q}$)**



$$Q = \frac{P_{xy}^2 + P_{xz}^2 + P_{yz}^2}{P_{\perp}^2 + 2P_{\perp}P_{\parallel}};$$

Swisdak, 2016

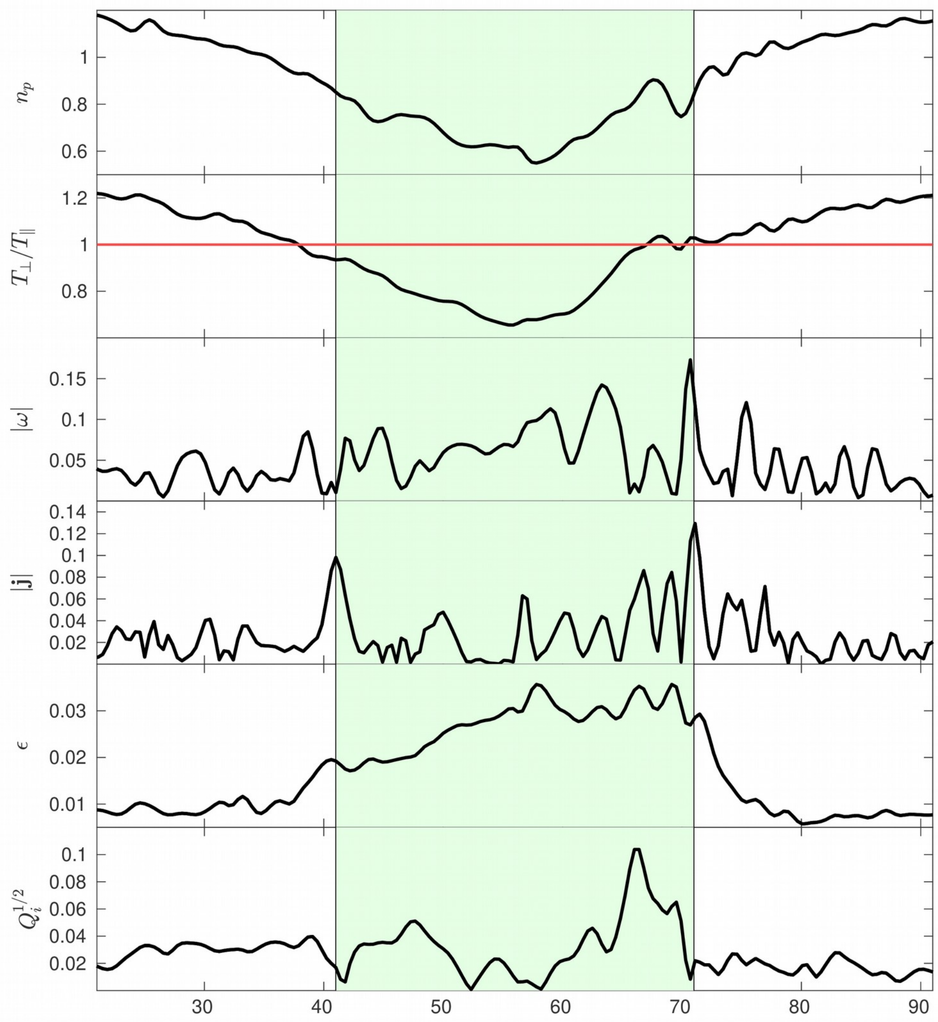
Cut of the VDF at the time of maximum **j** and at the spatial point of maximum ε

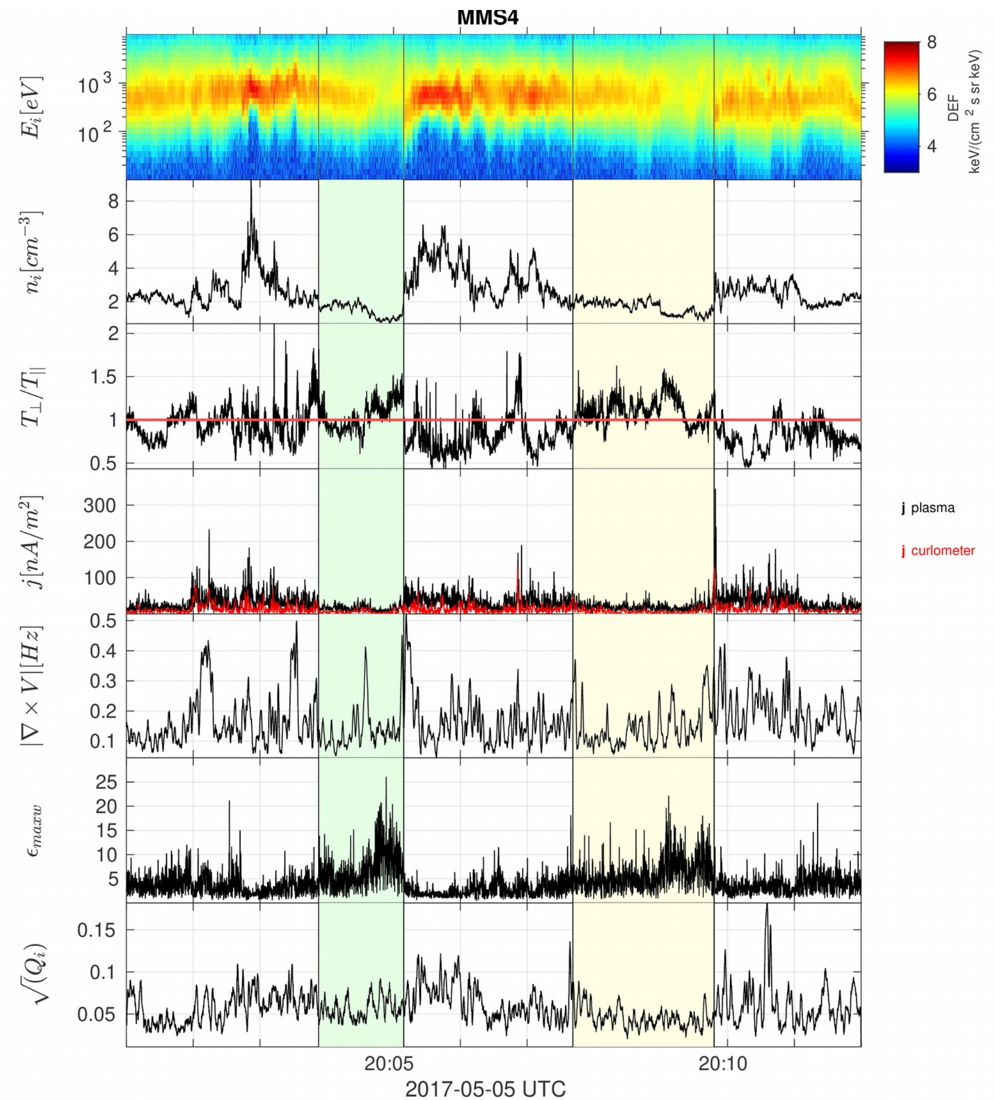


Settino et al. ApJ, 2020a

KHI in simulation and observational data

Comparison with KH vortices identified by *Hwang* et al. 2020





Settino et al. (2020b), to be submitted

Ion mixing in KHI detected by MMS

Mixing parameter for ions and electrons:

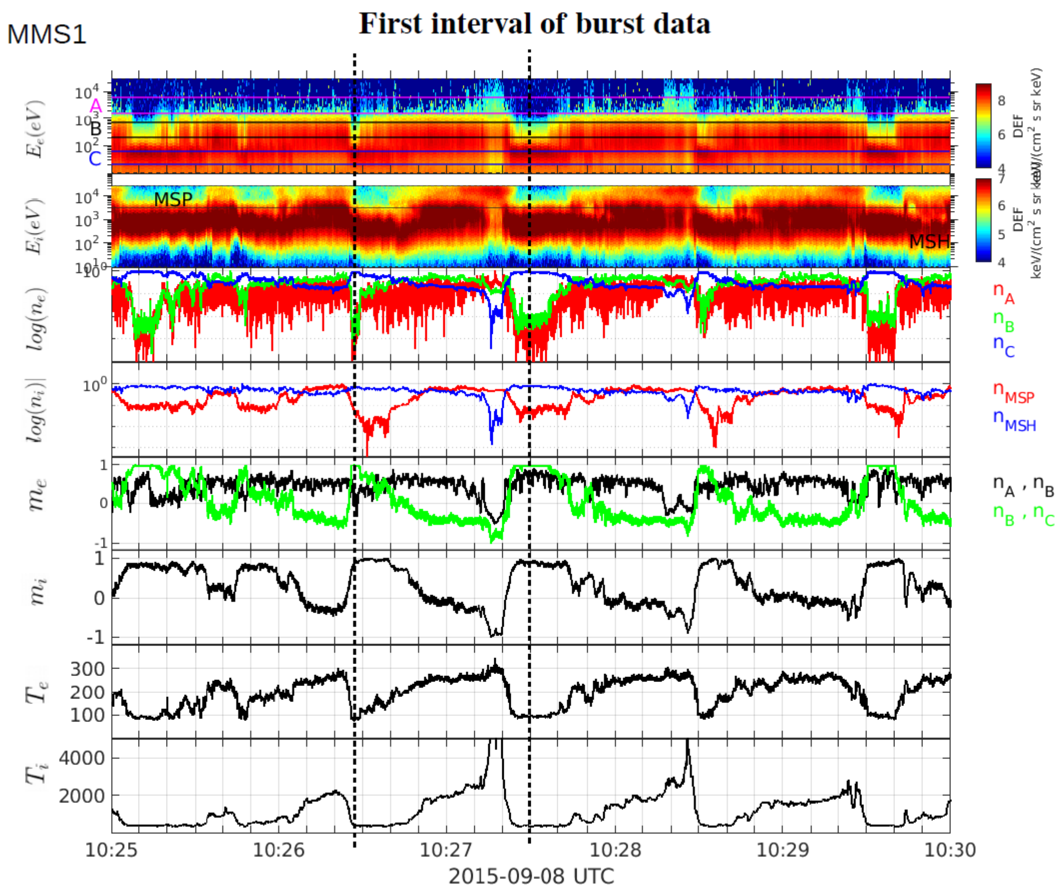
(Introduced by Nakamura et al.)

$$m_i = \frac{n_i^{MSH} - n_i^{MSP}}{n_i^{MSH} + n_i^{MSP}}$$

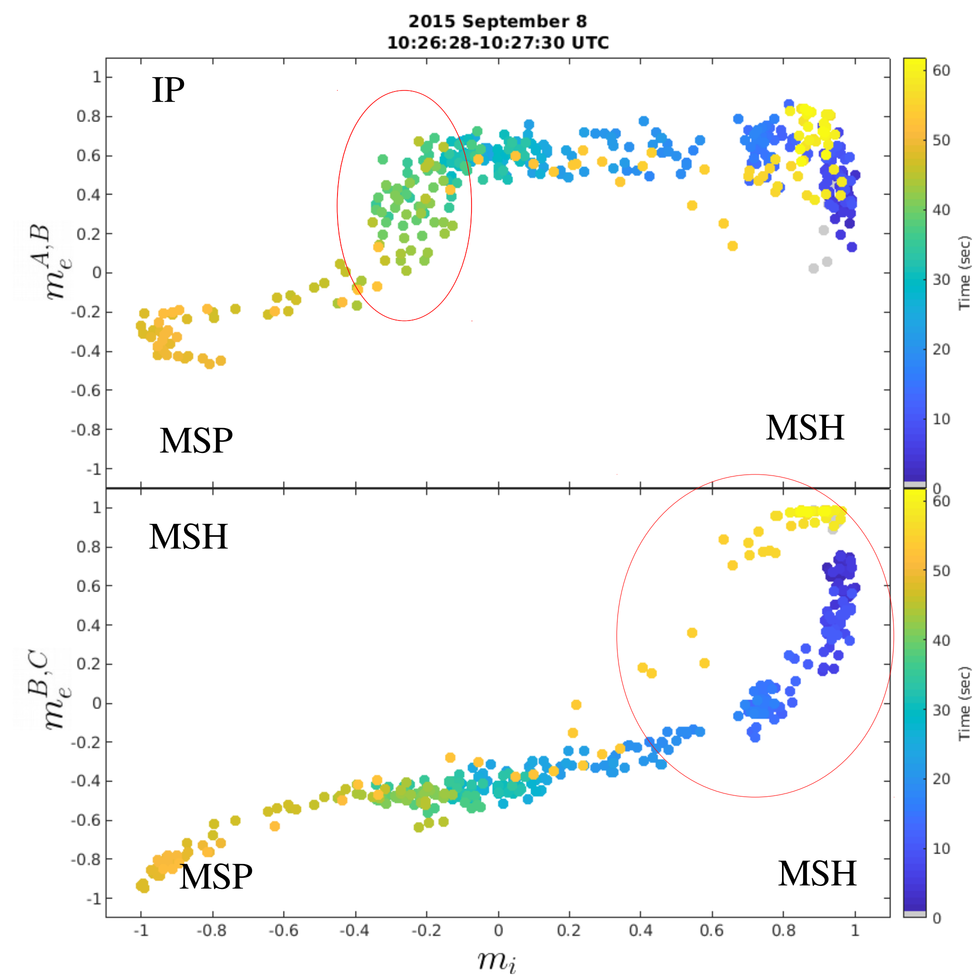
$$m_e^{B,C} = \frac{n_e^C - n_e^B}{n_e^C + n_e^B}$$

$$m_e^{A,B} = \frac{n_e^B - n_e^A}{n_e^B + n_e^A}$$

A → MSP
B → intermediate population (IP)
C → MSH



Settino et al. (2020c), in prep.



Summary

- Development of strong gradients are strictly connected to non-Maxwellian features;
- Local thermodynamical departures are observed in the proton distribution function;
- Identification of KH vortices from in-situ data using kinetic features of KHI;
- Identification and characterization of KHI dynamics, in MMS data, by means of the mixing parameters.