

Examining Interchange at the Outer Planets using JERICHO: a Kinetic-Ion, Fluid-Electron Hybrid Plasma Model

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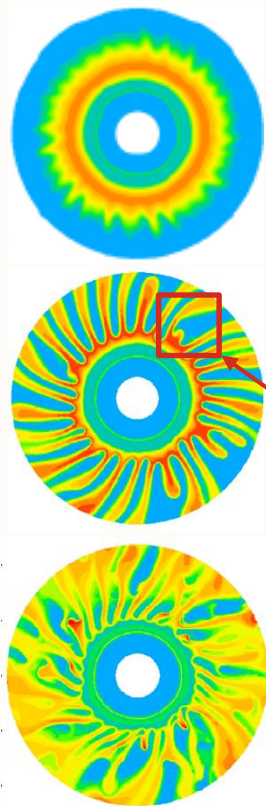


[JAWiggs](https://twitter.com/JAWiggs)



[JoshWiggs](https://github.com/JoshWiggs)

Radial Interchange at the Outer Planets



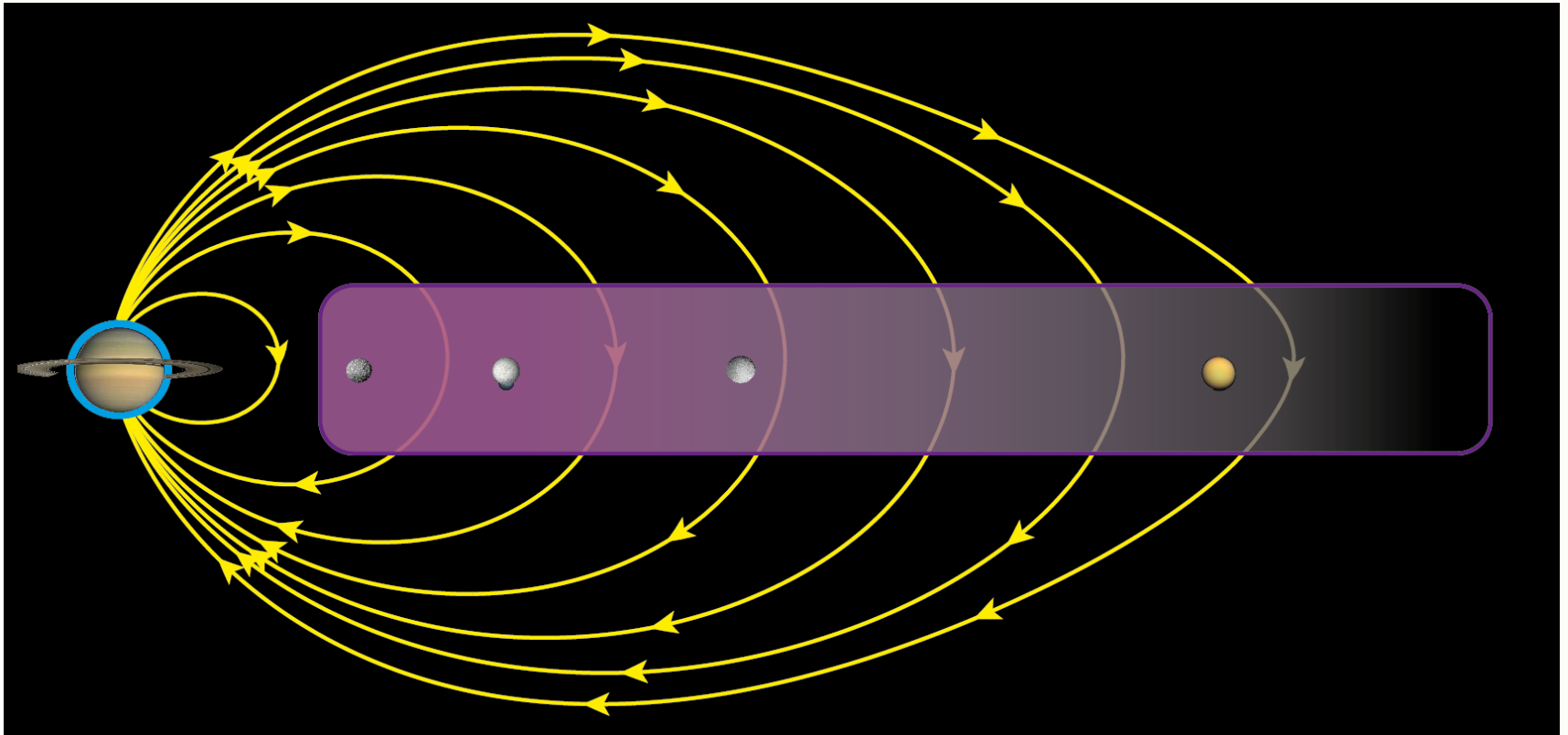
- Have plasma sources in inner magnetospheres of Jupiter and Saturn
- Plasma is transported into middle and outer magnetosphere by RI instability

What's happening inside here? Region is too small to probe with current state-of-the-art

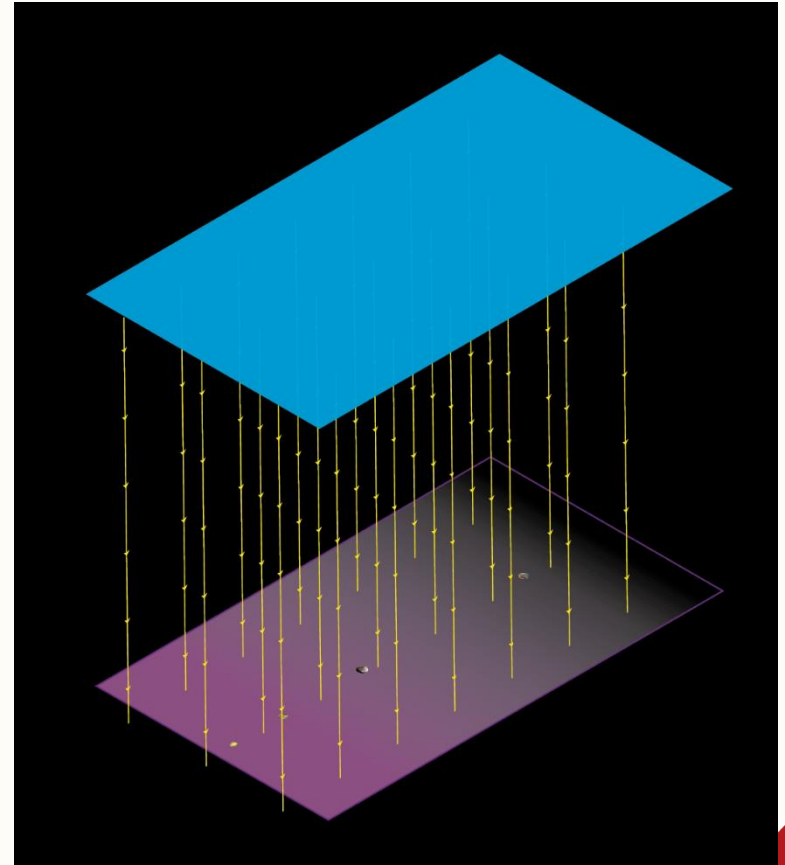
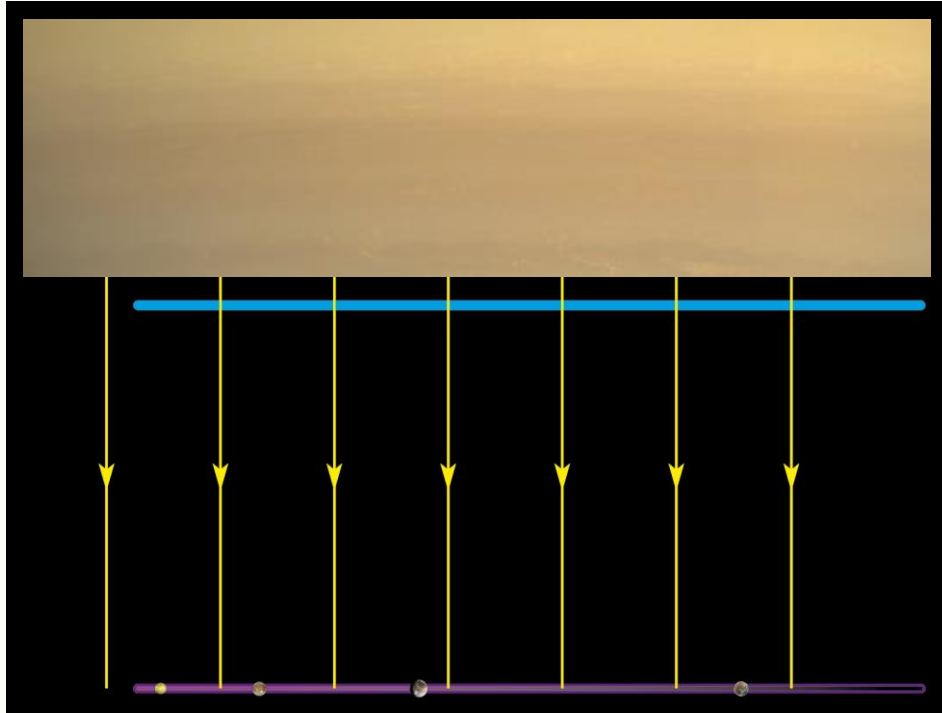
$$\underline{F}_{cf} \cdot \nabla \int \left(\frac{\rho}{B} \right) ds \geq 0$$

Southwood & Kivelson 1987, Achilleos+ 2015

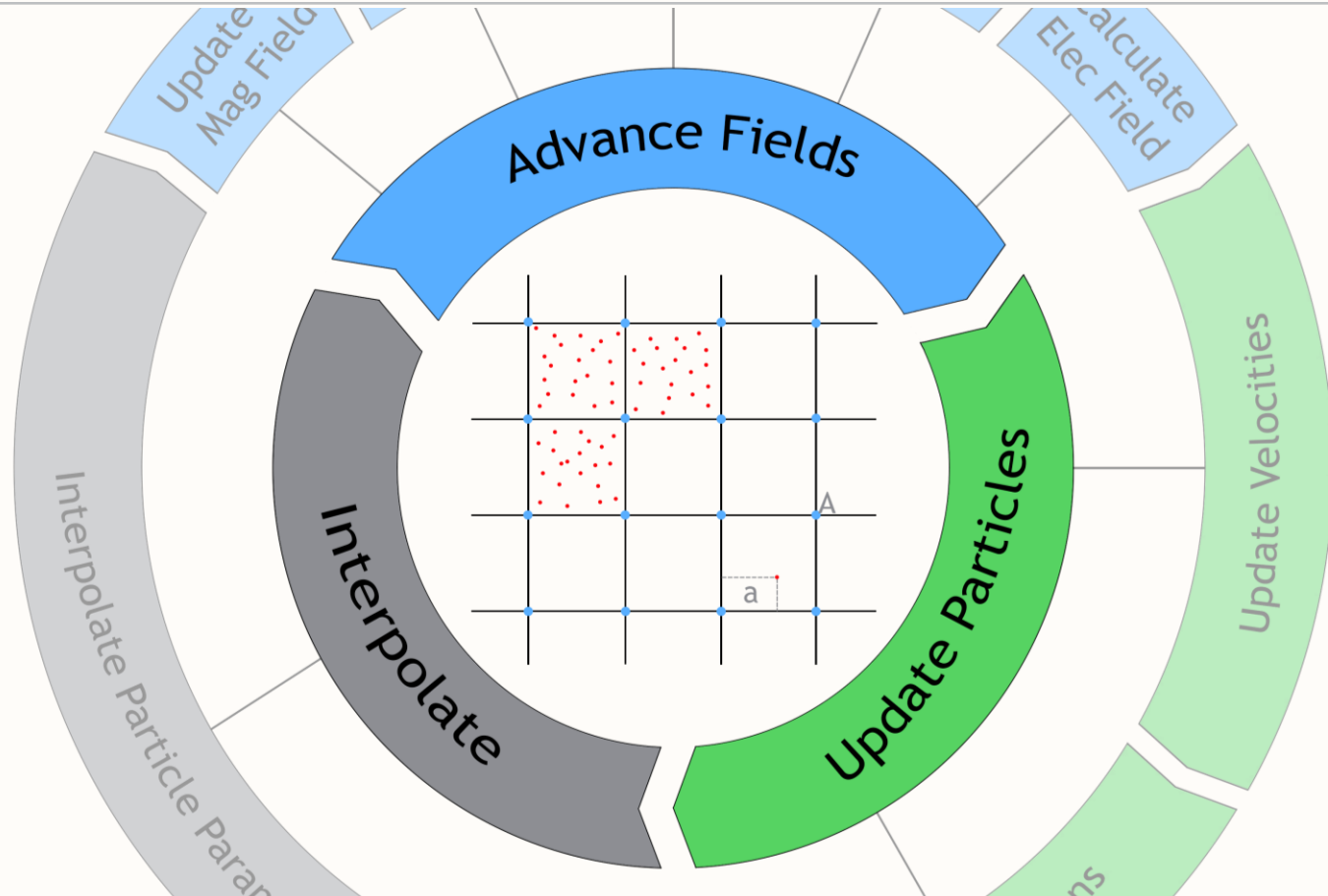
JERICO – Model Topology



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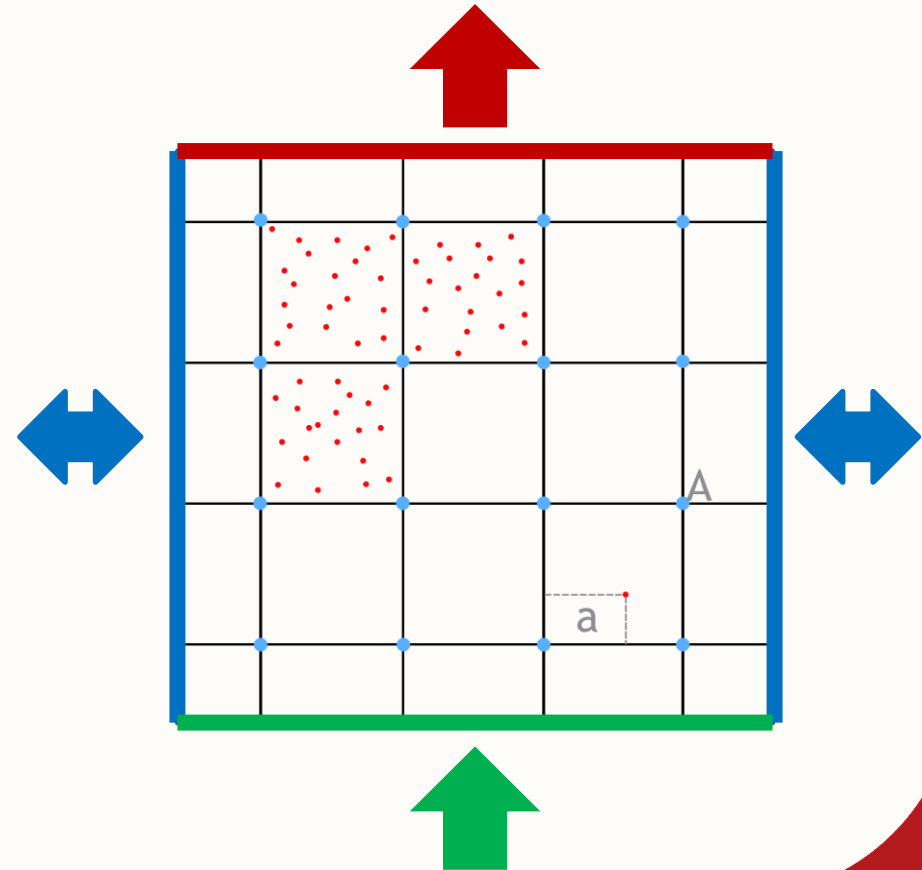


JERICO – Kinetic Ion, Fluid Electron



What controls size and propagation of instabilities

- Initial conditions set for Saturn (*Wilson+ 2017, Persoon+ 2020*)
- Left & right boundaries are **periodic**, plasma source placed at **bottom** ($7.5R_S$), **outflow** allowed at top ($9.5R_S$) (*Azari+ 2018*)
- Plasma source pulsed over course of simulation run, enhancements in plasma density induces interchange instability

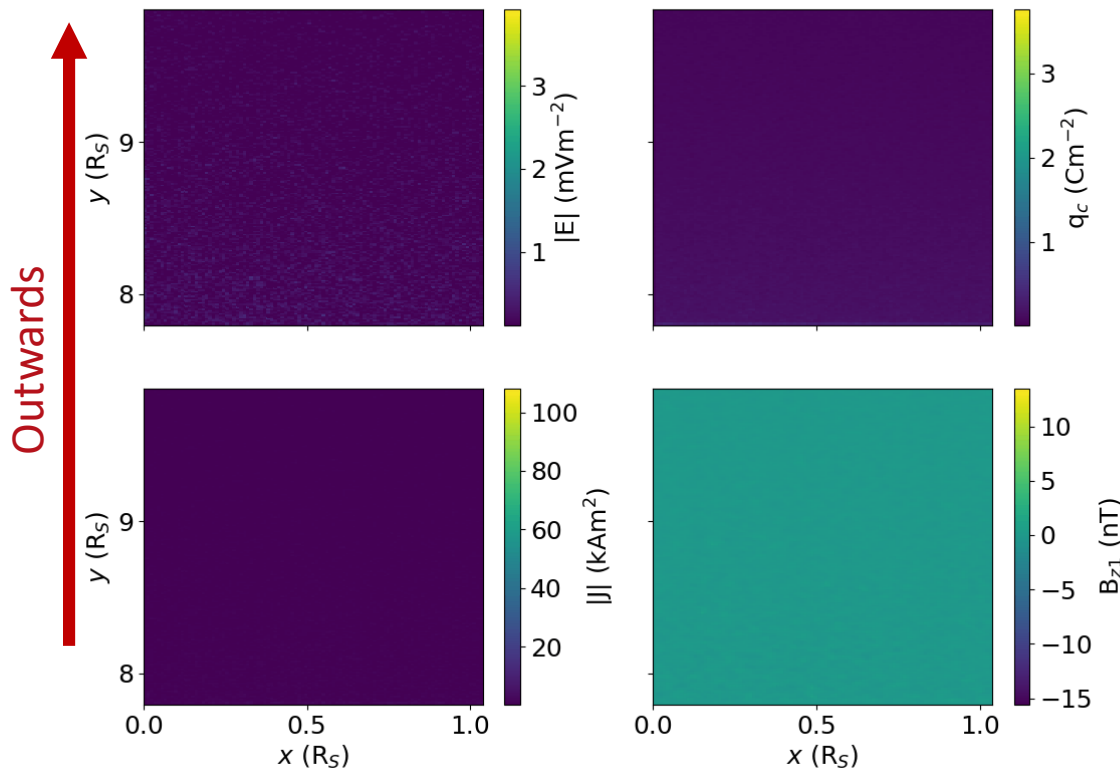


Radial-Interchange Instability – Model Run

$t = 1.0\Omega_i$

$$\Omega_i^{-1} \approx 33s$$

Electric Field

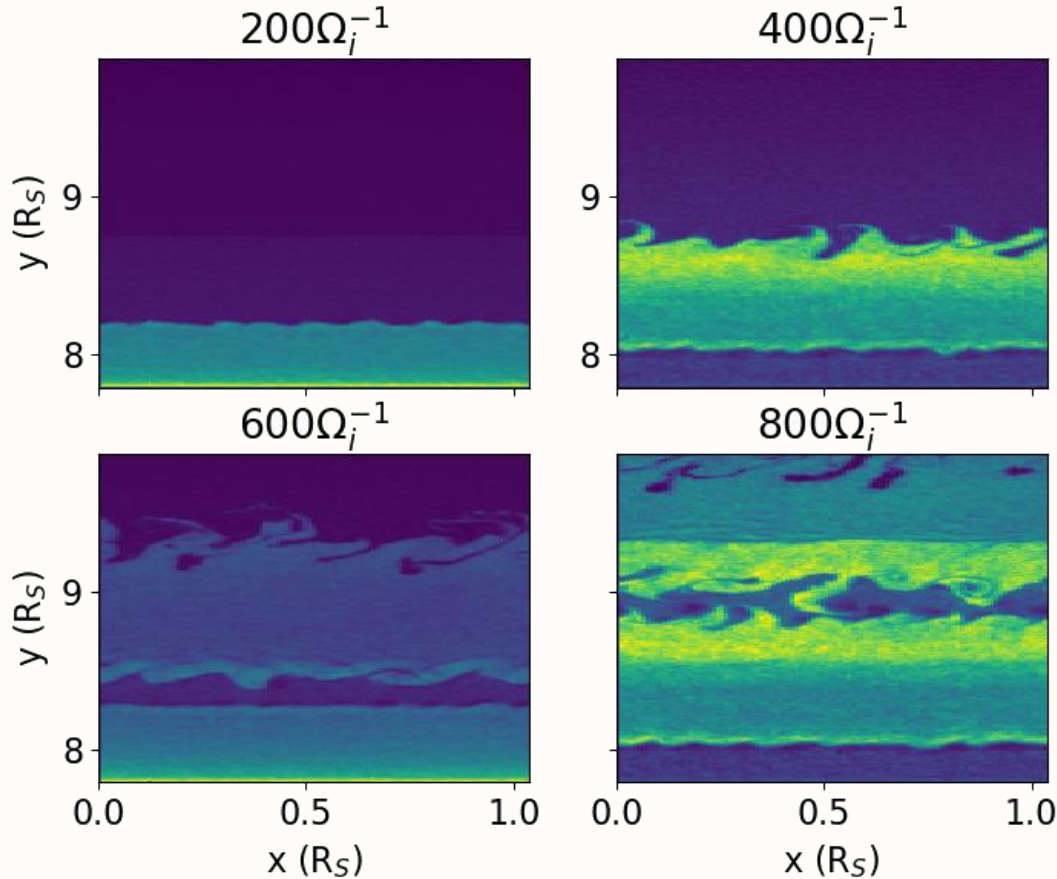


Charge Density

Current Density

Magnetic Field Perturbation

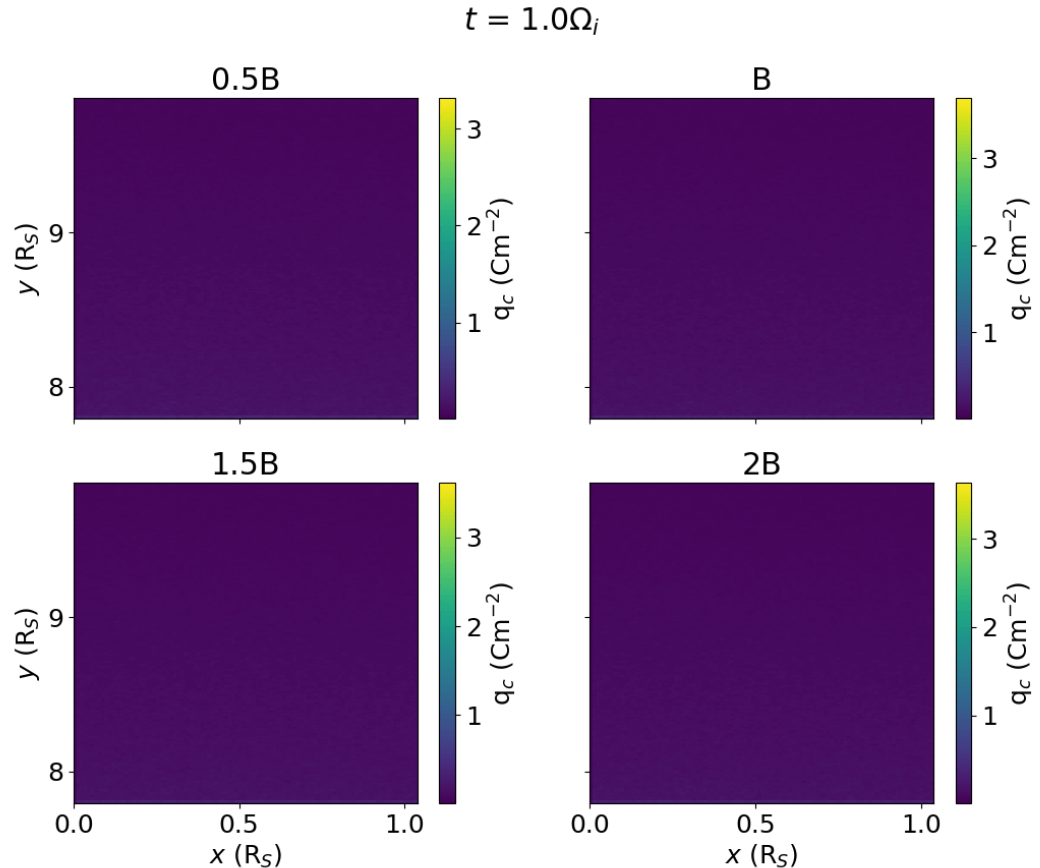
Radial-Interchange Instability – Initial Analysis



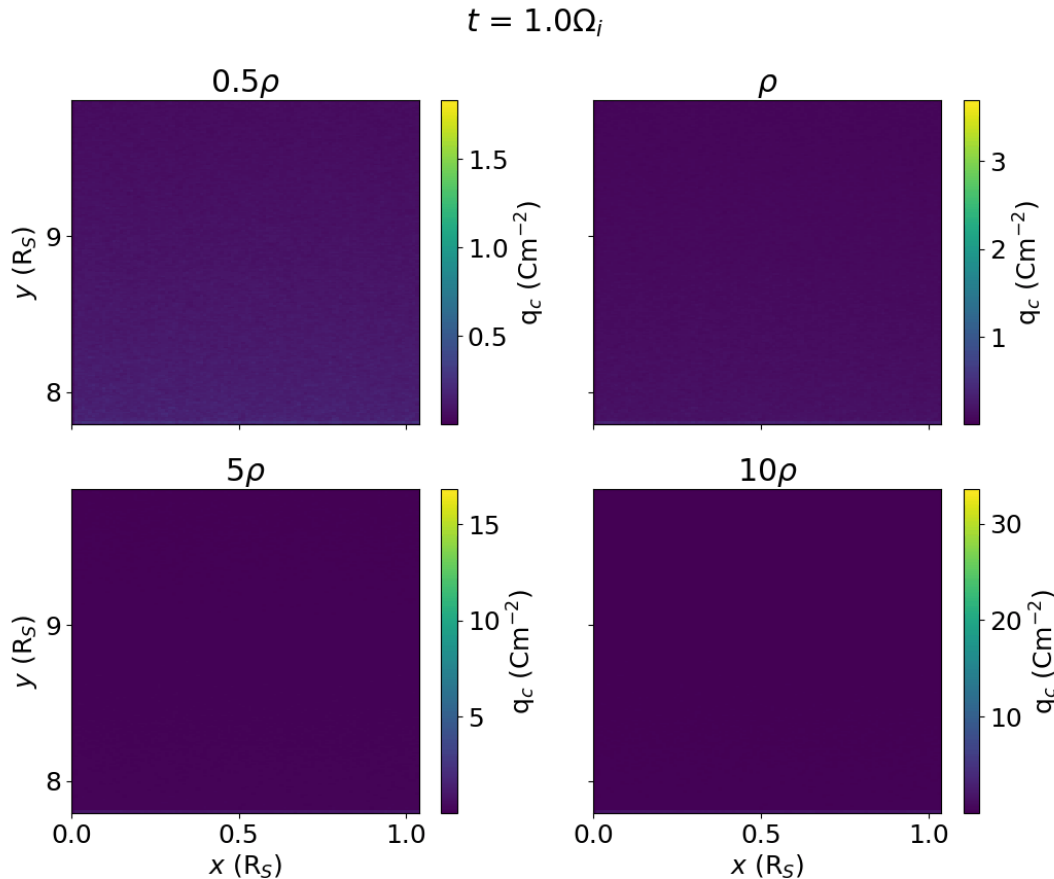
- On order 10 instabilities form on front of plasma injection
- No gravity included and no velocity shear along interface of injection
- Narrow channels of tenuous plasma form between dense fingers

Magnetic Field?

- Varied strength of initial magnetic dipolar field
- Both length and temporal scale for development of instabilities remains constant
- Stronger fields act to retard outwards flow of injected plasma



Plasma Source Density?



- Varied density of plasma injected from source at boundary
- Both length and temporal scale for development of instabilities remains constant
- Denser injections spread to occupy larger domain spaces

Summary

- We have developed a 2.5D ion-kinetic, fluid-electron hybrid plasma model in c++ [*in prep, Wiggs & Arridge*]
- Plasma source placed at bottom injects high density region on the leading and trailing edge of which ~ 10 instabilities form ($\sim 0.1R_S$) spontaneously form
- Varying both magnetic field strength & injected plasma density does not significantly alter spatial or temporal scales
- Development ongoing – Parallelise to increase simulation size (RAM bound), polar-cylindrical coordinates, ionosphere, Jovian ICs

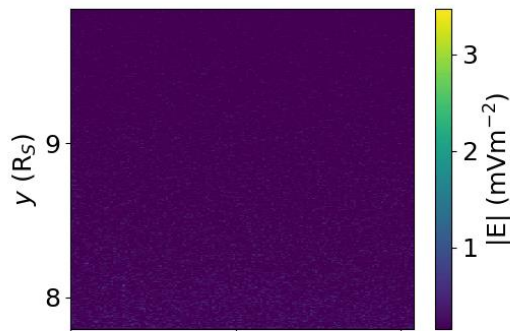


Backup

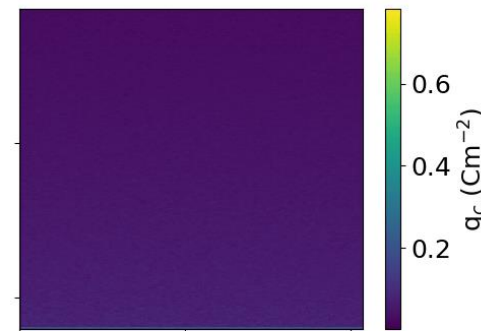
Parameter Survey – Resolution Change

$t = 1.0\Omega_i$

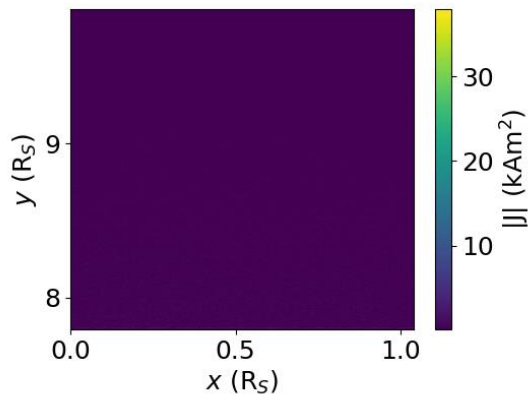
Electric
Field



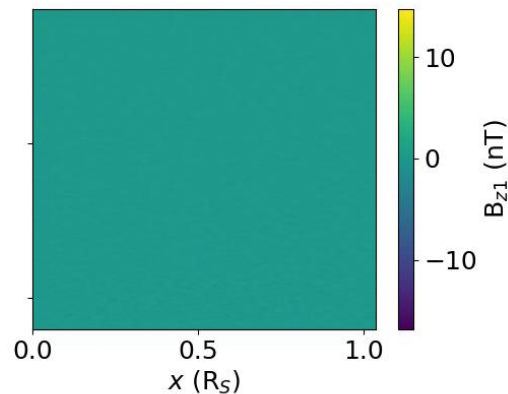
Charge
Density



Current
Density

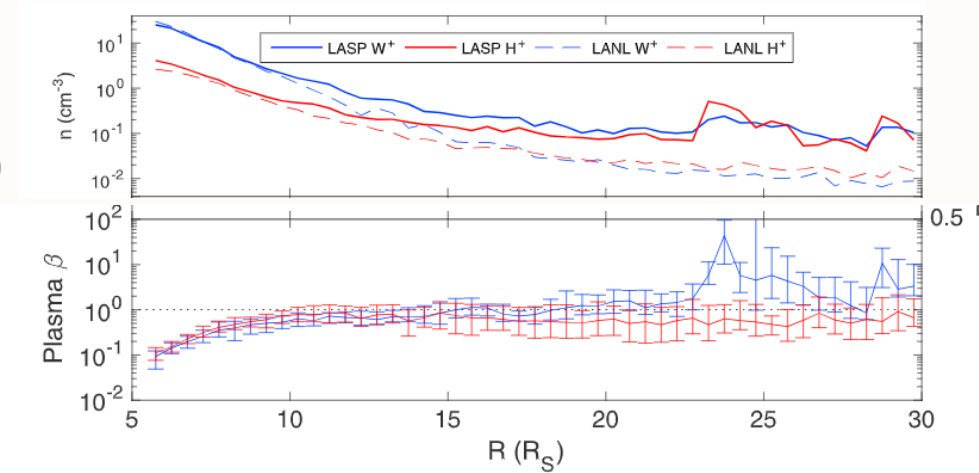


Magnetic Field
Perturbation



What controls size and propagation of instabilities

- Initial conditions set for Saturn (*Wilson+ 2017, Persoon+ 2020*) between $7.5R_S$ - $9.5R_S$ (*Azari+ 2018*)
- Periodic boundaries on left-right boundaries, plasma source places at bottom, outflow set at top
- Plasma source pulsed over course of simulation run, enhancements in plasma density induces interchange instability



Wilson+ 2017