Plasma for the space exploration

On the Hall effect thruster performances

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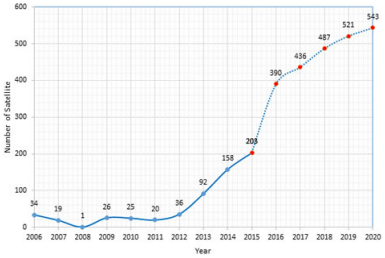
Propulsion for satellites

Introduction

- Increasing use/need satellite
- Propulsion is key : life time, capability, etc.



The Hall effect Thrusters

Introduction

- Space exploration need ever better thrusters to propel spacecraft behong the limits
- Hall Effect Thrusters (HET) is a very promissing technology :
  - High exhaust velocity ($\sim 12 km/s$)
  - Succesfully used since 1970s
  - *Smart1* spacecraft used it to the moon (ESA, 2009)

Exhaust velocity	Dry mass	mass at launch
$1 km/s$	$2T$	$5T$
$10 km/s$	$2T$	$3T$

However: **the HET is still poorly understood**

What don't we know ?

Introduction

Better inderstanding of HET is more and more important. However :

- Performance (thrust, efficentcy, etc.) isn't predictable yet
  - the wall effect is poorly understood
  - the electron mobility is anormaliously high ($\sim 10\times$)
- The life time isn't predictable
  - Walls are eroded by ion impact sputtering
  - Walls resistes from 1000 h to 7000h
  - Anormalous wall erosion are also observed

Why ? Because plasma physics are **difficult**

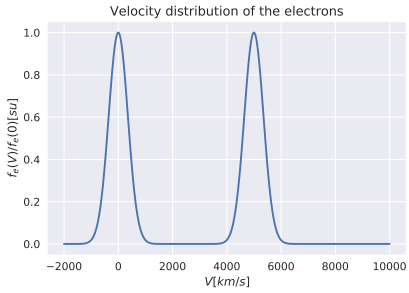
Plasma Beam Instability

Some Plasma Physics

An exemple of "simple" plasma behavious : the plasma-beam instability.

The system is simple:

- a static plasma background
- an electron beam with high velocity $v_b >> v_{th}$
- Collision are neglected (low pressure)
- uniform density



Plasma Beam Instability

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LPP

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Hall Effect Thruster : presentation

More details

Figure: Hall Effect Thruster (PPS-1350, Safran)

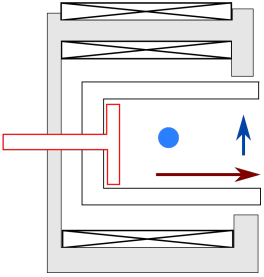
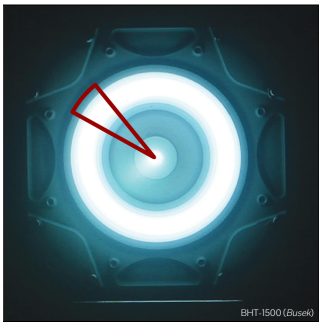


Figure: Shematic cut of an HET

Simulation presentation

Investigating the ECDI

Investigating the Electron Cyclotron Drift Instability (ECDI)



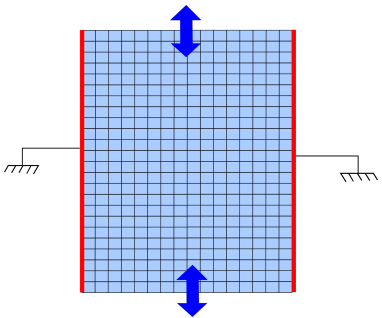


Figure: Shematic cut of the simulation

Simulation results

Investigating the ECDI

The Density evolution in function of time.

Simulation results

Investigating the ECDI

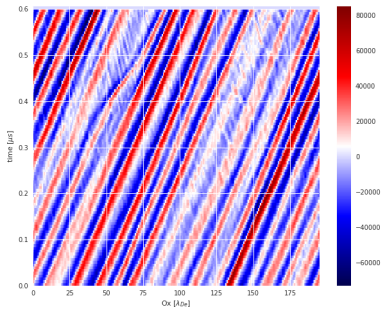


Figure: Evolution of E_θ function of t and θ.

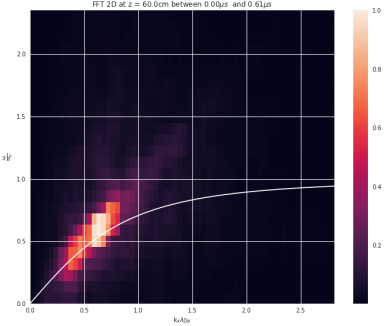


Figure: Fourier Transform of E_θ.

There Is No Largest Prime Number

The proof uses *reductio ad absurdum*.

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1. Suppose p were the largest prime number.

4. But $q + 1$ is greater than 1, thus divisible by some prime number not in the first p numbers.

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A longer title

- one
- two