SPIS applications for HPH.com project

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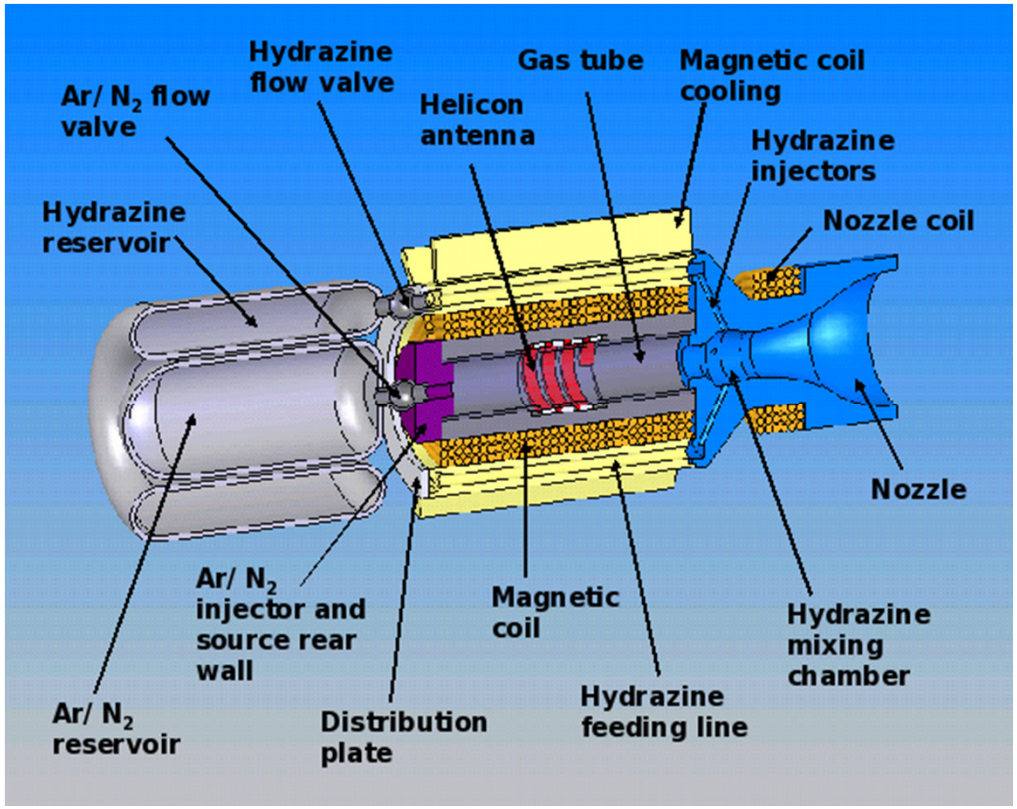
Introduction

- Helicon Plasma Hydrazine. COmbined Micro (HPH.com)
  - EC FP7 funded
  - 16 partners
  - project main goal

    is design, optimization, and development of the low-power (50W) helicon thruster
  - other goals are

    applications, missions



AOES contributions

- Numerical modelling of ion detachment in magnetic nozzle
  - XOOPIC software, UC in Berkeley
  - Presented at IAC-2011
- Numerical analysis of helicon plasma/ secondary propellant interaction
  - Home-grown codes
- Numerical analysis of secondary propellant decomposition due to heating
  - Home-grown codes
- Numerical modeling of plasma spacecraft interaction taking into account helicon thruster firing
  - SPIS, XOOPIC/ONERA code, dsmcFoam

Spacecraft plasma interaction

- Electric propulsion engine emits plasma and neutrals that leads to charge exchange (CEX) ions.
- The plasma can expand around spacecraft and change plasma environment and spacecraft potential.
- The higher plasma density can also lead to attenuation and reflection of RF transmission and reception
- Numerical modeling can help to predict and assess these effects

Satellite and orbit

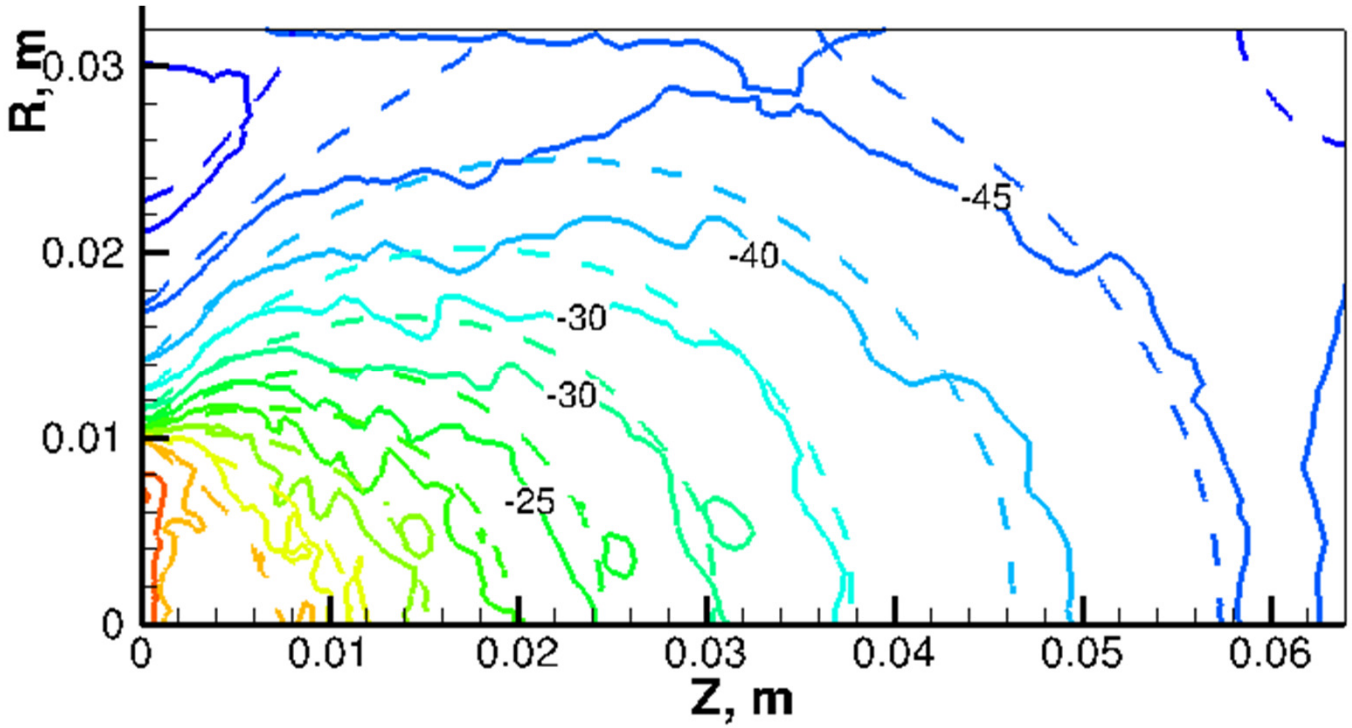
- Circular orbit (about 660 km)
- Inclination: any
- Ambient plasma properties
  - Demeter satellite

SPIS

- Version 4.3.1
- Modifications
  - Species properties (density, velocity, temperature) sampled over many time steps
  - Constant weights for ambient electrons and ions
  - Fixing in multiple source (fool-proof)

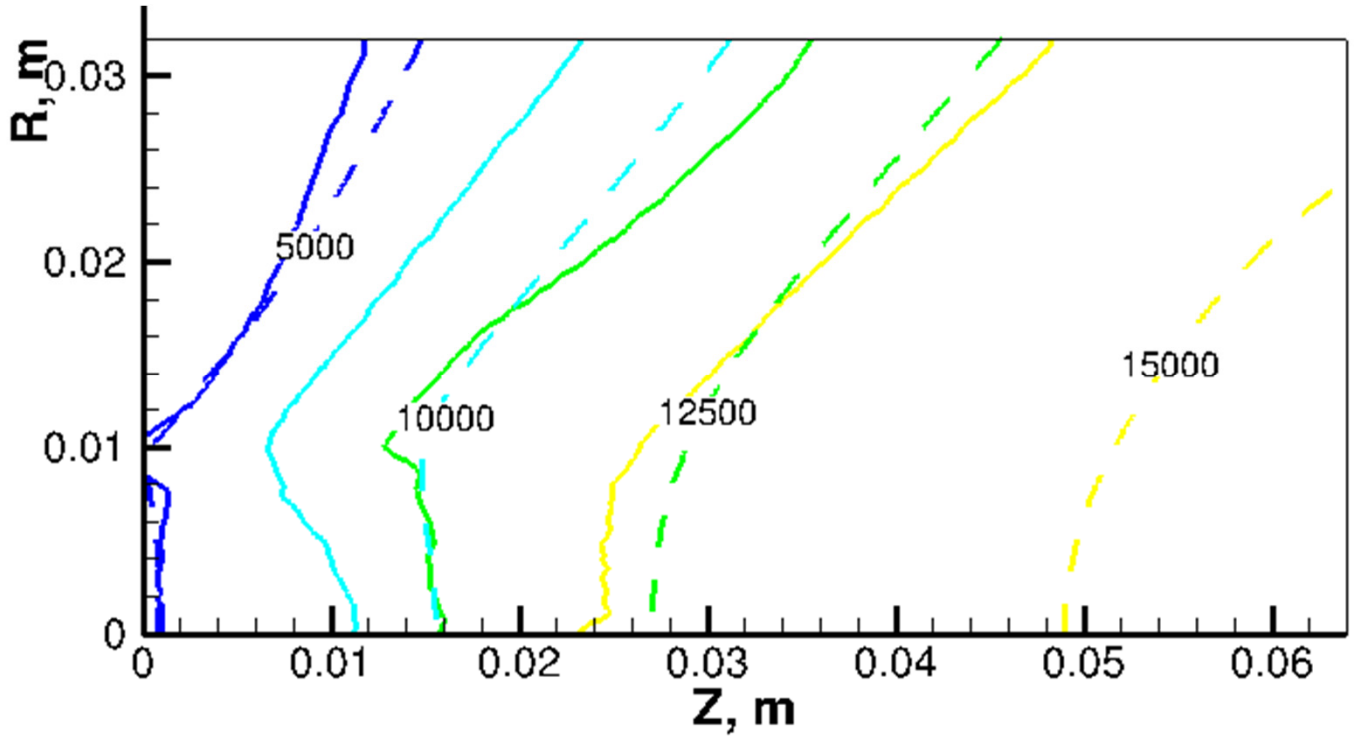
    #242 in SPIS bugs tracker

Validation: plume case



- Potential (solid lines, SPIS; dashed lines, XOOPIC)

Validation: plume case



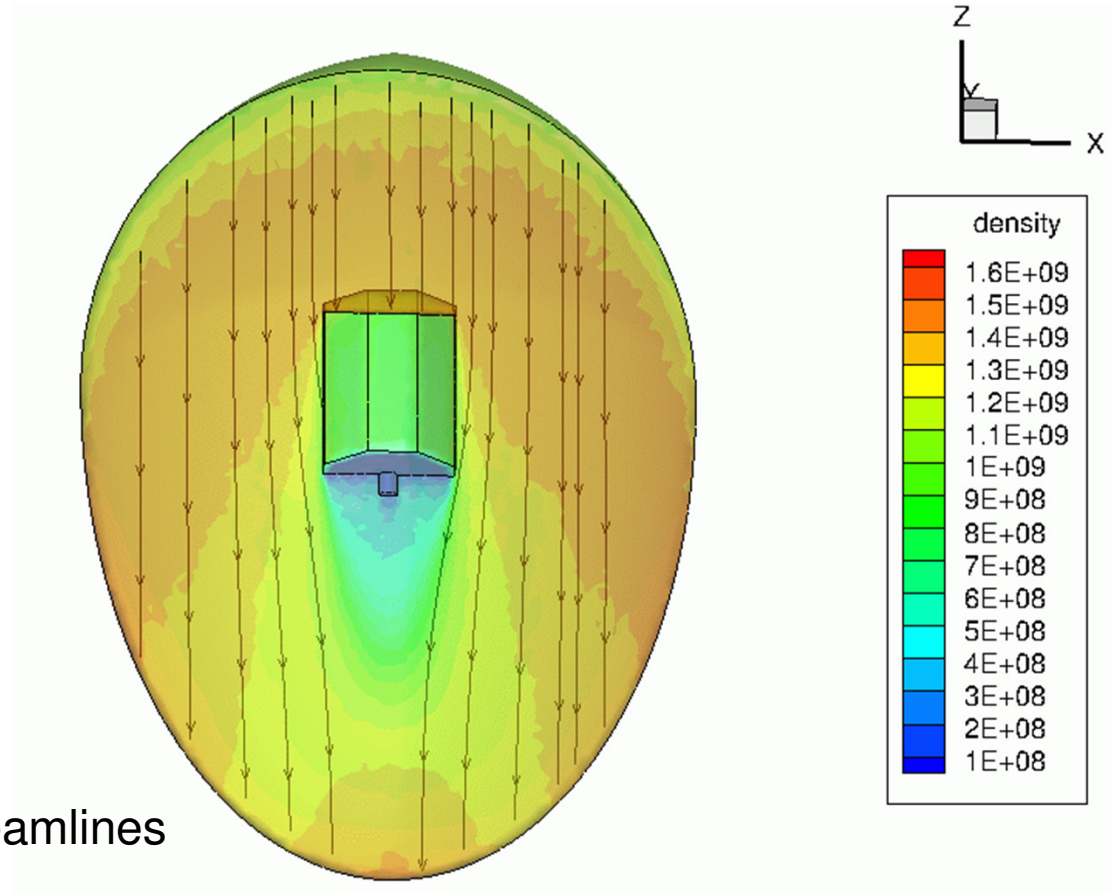
- Axial velocity (solid lines, SPIS; dashed lines, XOOPIC)

Validation: plume case

- XOOPIC mesh is more refined (256x128)
- SPIS mesh is ¼ cylindrical segment with 570,000 tetrahedrons
- For narrower segment, GMSH generates a badly defined mesh.
  - nodeVol: listed as #243 in SPIS bugs tracker
  - gmshToFoam: undefined faces in mesh
  - MeshInspector?

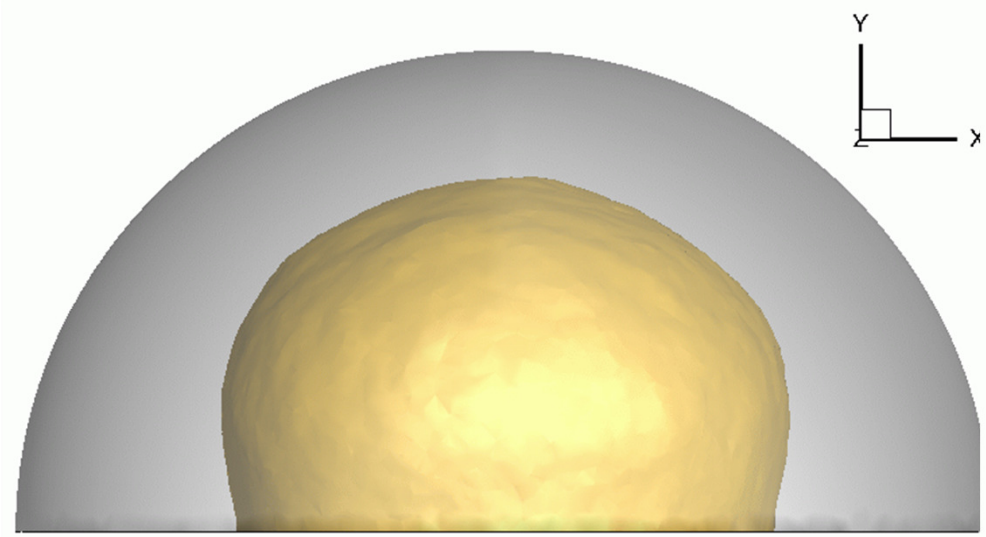
No thruster firing

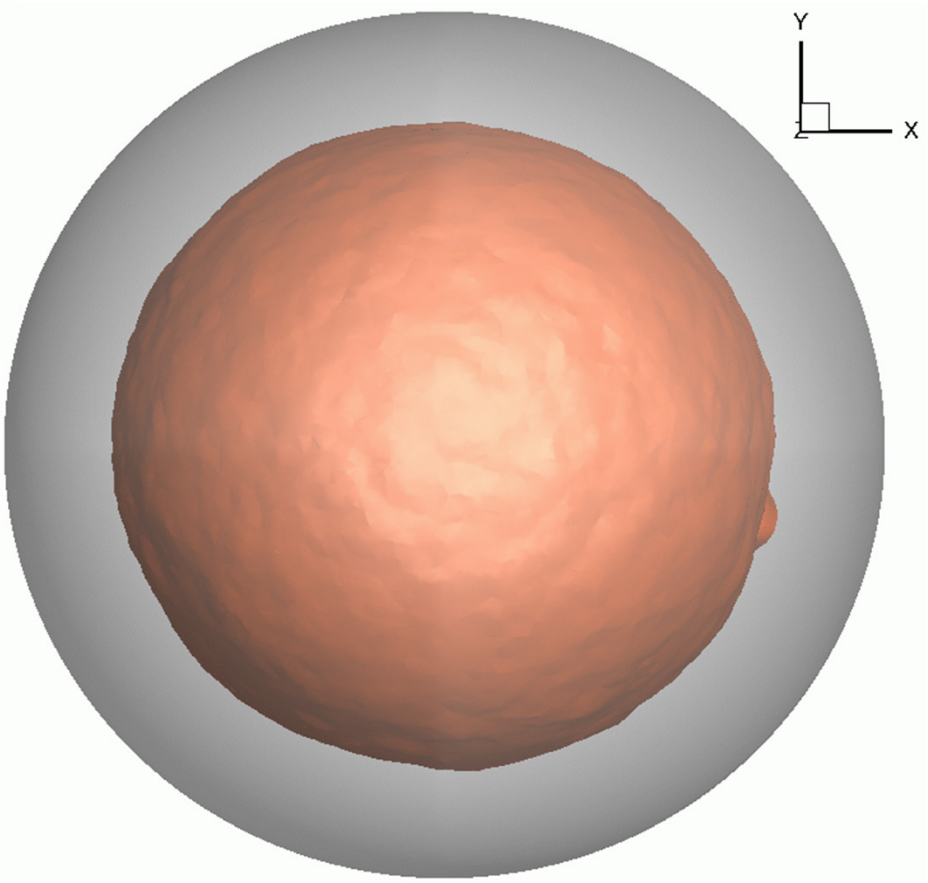
- Potential about -0.6 V



Ion density and selected streamlines

No thruster firing (cont.)





- Symmetry plane effects
  - Isopotential shape
  - Spacecraft potential?

Thruster firing

- Fixing potential on the specific surface when other surfaces are floating
  - I had a problem with fixing of potential at the thruster exit
  - SPIS forum has included a discussion and a suggestion was given by Jean-Charles Mateo-Velez

Thruster firing (cont.)

- Computations
  - Only beam ions
  - Beam (90%) and slow (10%) ions
- Slow ions ≠ CEX ions
- Mesh can not be resolved enough in the plume area due to single processor use
- Implementation of Markelov&Gengembre, Modeling of plasma flow around SMART-1 spacecraft with SPIS software, IEEE TPS (2006)

Thruster firing (cont.)

	2005	2012
Neutral flow	SMILE	dsmcFoam
Plasma plume	PICPlus	XOOPIC and ONERA fluidic code
Spacecraft plasma interaction	SPIS 3.1.01	SPIS 4.3.1

SPIS further development

SPIS is much better than it was in 2005!

Formally no limit on memory but it is a single processor code.

- Parallel version, PARALLEL version
  - Now any computer is parallel
- Dump files (automatic and manual options)
  - Stop& Continue with different options
  - Parametric studies
  - Computer crashing down
- Surfaces with fixed potential in the case of floating potential computations
- Symmetry plane
- Improvement of mesh analysis/checking?

Conclusions

- SPIS has allowed us to perform computations of plasma spacecraft interaction at LEO and with electric propulsion thruster firing.
- However, it takes a lot of computational time and parallel version of SPIS is very needed.
- Some problems have been met and further SPIS development and improvement are desirable.

Thank you all

and Julien Forest, David Rodgers and Fabrice Cipriani!

Acknowledgements: The research leading to these results has received funding from the European Community's Seventh Framework Programme (SPACE - FP7/2007-2013) under grant agreement n° 218867