



SPIS Status

22nd SPINE meeting, Toulouse, March 23-24 2016

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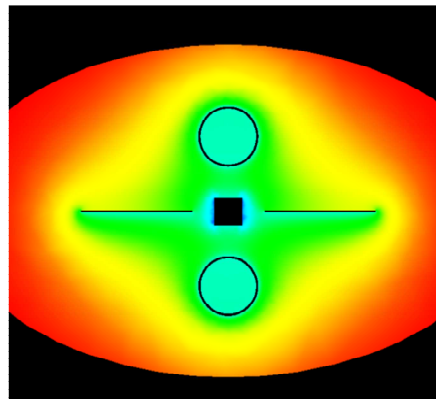
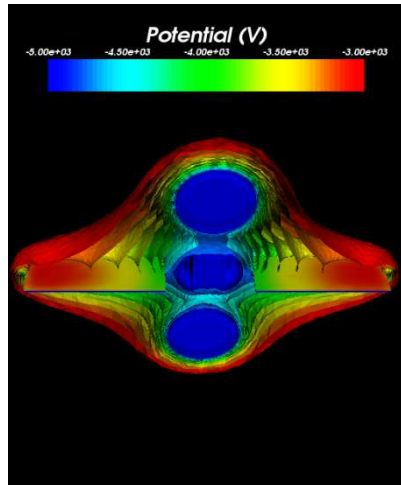


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What is SPIS ?

- Spacecraft Plasma Interaction Software includes physics
 - 3D and dynamical modelling of the surrounding plasma sheath
 - Particles and current collections
 - Surface effects and secondary emissions
 - Internal electrical balance
 - Active sources
- SPIS architecture is
 - Based on a numerical kernel, SPIS-NUM, an electrostatic 3D unstructured electrostatic Particle-In-Cell plasma model
 - Fully developed on a Java-based highly modular Object Oriented library
 - Include a complete Integrated Modelling Environment (IME), SPIS-UI:
 - Pre-processing (CAD, meshing, IBCs settings, simulation settings...)
 - Simulation control and monitoring
 - Data-mining and post-processing
- SPIS software is open-source project

SPIS quick overview

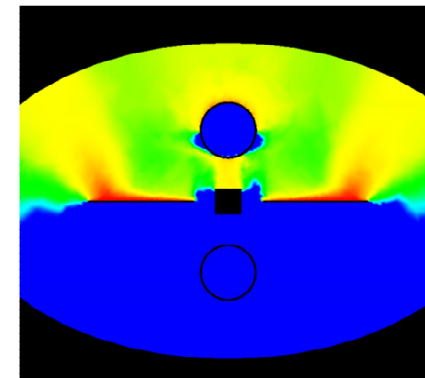
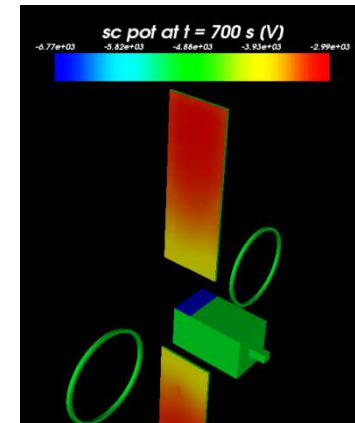


①
Electric field from:
-Particle densities
-Boundary conditions

④
Potential on S/C:
-Current balance
-RLC circuit between S/C elements

②
Particle Transport:
-Space environment
-Secondaries or Sources from S/C

③
Interaction with S/C:
-SEE by electrons
-SEE by protons
-Photo-emission
-Sources
- Erosion

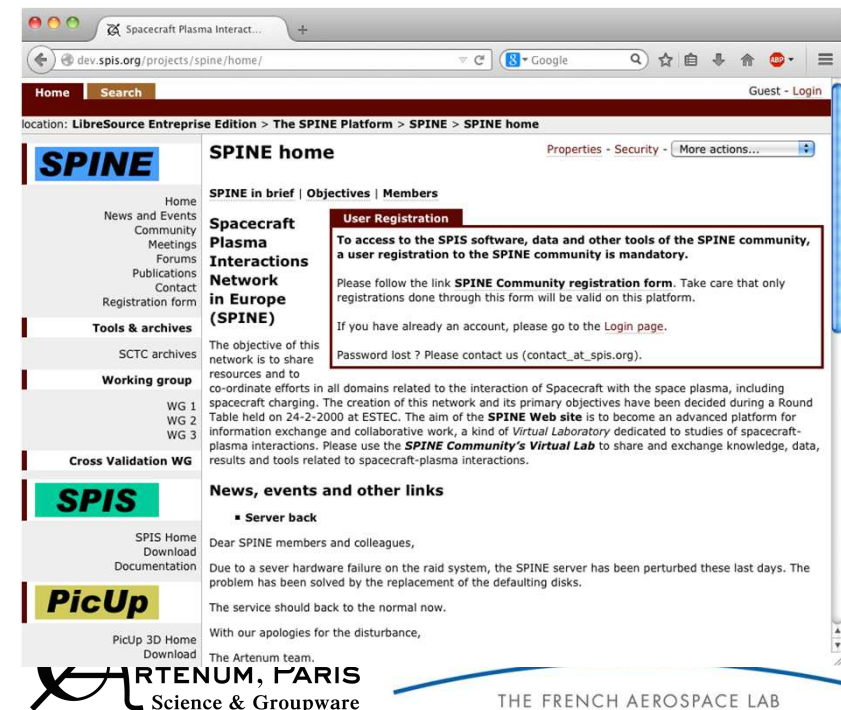


Historical context

- **SPIS**
- Initiated in 2001 by ESA, with support of CNES
- About 10 major releases since 2003
- More than 8 500 downloads (all versions/branches included)
- More than 1 300 downloads for SPIS 5.1.8
- Open to various fields: ESD, instrument calibration, propulsion, dusty plasmas, internal charging.
- Various flavours
 - SPIS-GEO
 - SPIS-Science
 - AISEPS
 - SPIS-Dust (To be released)
 - SPIS-IC (To be released)
- Components mutualised with other scientific communities

SPINE, an active community

- <http://dev.spis.org>
- More than 900 registered members (and around 2 new registrations a week)
- About 20 active contributors (including SMEs, major industrial actors and academics)
- Regular SPINE meetings
- Many publications (~10 at next SCTC !!)



The screenshot shows a web browser window displaying the SPINE website. The URL is <http://dev.spis.org/projects/spine/home/>. The page features a navigation menu on the left with links for Home, News and Events, Community, Meetings, Forums, Publications, Contact, and Registration form. Below the menu are sections for Tools & archives, Working group, and Cross Validation WG. The main content area is titled "SPINE home" and includes a "User Registration" notice. The notice states: "To access the SPIS software, data and other tools of the SPINE community, a user registration to the SPINE community is mandatory. Please follow the link SPINE Community registration form. Take care that only registrations done through this form will be valid on this platform. If you have already an account, please go to the Login page. Password lost? Please contact us (contact_at_spis.org)." Below the notice, there is a "Server back" announcement: "Dear SPINE members and colleagues, Due to a sever hardware failure on the raid system, the SPINE server has been perturbed these last days. The problem has been solved by the replacement of the defaulting disks. The service should back to the normal now. With our apologies for the disturbance, The Artenum team." The footer of the page includes the Artenum logo and the text "ARTENUM, PARIS Science & Groupware" and "THE FRENCH AEROSPACE LAB".

What SPIS is good at

- SC charging in GEO
 - From ESTEC/ESA contract finished in 2013 (D. Rodgers) and from initial contracts (ESA, A. Hilgers / CNES, D. Payan)
 - Simplified use for industry → SPIS 5 version
 - 10+ publications in scientific journals : comparison with NASCAP, LANL spacecraft data, electron emitter assessment, ...
- Scientific missions dealing with low energy plasma measurements
 - From ESTEC/ESA contract finished in 2014 (A. Hilgers)
 - Lots of scientific tools → SPIS 5.1.8 version (last available)
 - 5+ publications in scientific journals: LEO Cubesat charging, Solar orbiter, Juice, ...
- Ground plasma tank
 - Detailed characteristics of plasma chambers and particles sources (ion and electron guns) and instruments (LP, RPA, KP)
 - 5+ publications in scientific journals: electrodynamic tether, secondary electron emission yield, surface potential ...

What SPIS can be quite good at

- Plasma thrusters interaction with spacecraft (charging, efficiency, erosion, contamination)
 - From ESTEC contract finished in 2012 (E. Gengembre) lead by Airbus DS
 - Database of thrusters available on demand at ESA
 - Updated model for electron cooling, Charge exchange reaction
 - Included in SPIS 5 but miss important physics however → one objective of this meeting is to tell what
 - A few papers in scientific journals
- Thin elements
 - SPIS includes models for thin wires and thin panels (electric field and particle collection)
 - Assume long Debye length regime to obtain analytical fits
- Quick overview of capabilities is now difficult to do → look at the html user guide

Coming soon

- SPIS 5.2

- From ESTEC contract on Dusty plasma (F. Cipriani)
- Of course, totally different physics is included : dust grain charging, surface contamination, lunar environments
- Improved solvers : robust particle pusher, stabilized circuit solver (even though still improvable)
- New UI capabilities
- Experimental validation by PhD student A. Champlain started in 2013
- 2 publications in scientific journals

For users that are not interested by dusts:

The new capabilities **do not complicate the use of SPIS**

if you do not need it, you probably will not even see it

The **efficiency of SPIS for non-dusty simulations is not impacted**

memory usage is smaller and execution speed increased by ~10%

- SPIS 5.2 should be available by June this year after consolidation and non regression procedure

Parallel development

- SPIS Internal Charging
 - From 2 ESTEC contracts (G. Santin, D. Rodgers)
 - Change of paradigm : 3D charge transfer inside matter; enables computing days of charge and relaxation; mixed with SPIS Surface charging but one have to choose to perform either intern or surf charging (not both at the same time)
 - 2 communications in congress (1 at next SCTC)

On-going work at ONERA

- PhD thesis are on-going on the development of SPIS under CNES or Midi-Pyrénées Region grants: advanced numerical schemes allowing to solve more complex problems in realistic times
 - Patch method (A. Brunet – started 2014):
 - Advanced multi-domain method allowing to refine the mesh on particular locations (“patch”).
 - Small-scale systems simulation: SC interconnectors, sensors
 - Large-scale simulations: thruster plume, wake. . .
 - Hybrid method (O. Jorba-Ferro – started 2015):
 - Coupled fluid and perturbative-PIC method allowing the simulation of dense plasma flows
 - First targets are the MYRIADE spacecraft (TARANIS)
 - Models of material conductivity (R. Pacaud - started 2015):
 - Material conductivity physical and numerical modelling
 - Validation with experiments on space material
 - Impact of electron emission inside plasma thrusters (M. Villemant – started 2015)
 - Experimental investigations in new DEESSE chamber
 - 1D modelling of plasma thruster channel

Good start for

- Electric propulsion
 - From 2 ESTEC contracts (K. Dannenmayer, A. Hilgers)
 - Challenging projects long awaited by all the European space industry
 - Release candidate expected end of 2017
 - You are all invited to
 - See presentations by P. Sarrailh and S. Hess
 - Participate to the discussion tomorrow on “Development of a SPIS version dedicated to plume-spacecraft interaction”
- SPIS-Services commercial offer by ARTENUM and ONERA
 - Since 2014
 - Training (GEO, LEO, EP)
 - One-year user assistance
 - New modules (as eg geometry editors)